AD-A043 662 ARMY ARMAMENT RESEARCH AND DEVELOPMENT COMMAND ABERD--ETC F/G 13/2
PRELIMINARY ENVIRONMENTAL SURVEY OF VOLUNTEER ARMY AMMUNITION P--ETC(U)
AUG 77 E S BENDER, V J KELMECKIS
UNCLASSIFIED ARCSL-TR-77016 NL

| OF |

AD
A043662

END
DATE
FILMED
9-77
DDC

AD A043662

AD

(12)

TECHNICAL REPORT ARCSL-TR-77016

(EO-TR-77017)

PRELIMINARY ENVIRONMENTAL SURVEY OF VOLUNTEER ARMY AMMUNITION PLANT, TYNER, TENNESSEE, MARCH 1976

by

Edward S. Bender
Val J. Kalmeckis, SP5
Paul F. Robinson
Daniel D. Rieder, SP5
Robert J. Donald, SP4
Melvin W. Moore, SP5

Ecology Branch

August 1977

US ARMY ARMAMENT RESEARCH AND DEVELOPMENT COMMAND
Chemical Systems Laboratory
Aberdeen Proving Ground, Maryland 21010

Approved for public release; distribution unlimited.

Disclaimer

The findings in this report are not to be construed as an official Department of the Army position unless so designated by other authorized documents.

Disposition

Destroy this report when it is no longer needed. Do not return it to the originator.

UNCLASSIFIED

SECURITY CLASSIFICATION OF THIS PAGE (When Data Entered)

REPORT DOCUMENTATION PAGE

READ INSTRUCTIONS BEFORE COMPLETING FORM

14

1. REPORT NUMBER
ARCSL-TR-77016 EO-TR-77017

2. GOVT ACCESSION NO.

3. RECIPIENT'S CATALOG NUMBER

6

4. TITLE (and Subtitle)
PRELIMINARY ENVIRONMENTAL SURVEY OF VOLUNTEER ARMY AMMUNITION PLANT, TYNER, TENNESSEE, MARCH 1976.

9

5. TYPE OF REPORT & PERIOD COVERED
Technical Report.
February 1976-June 1976

6. PERFORMING ORG. REPORT NUMBER
EO-TR-77017

10

7. AUTHOR(s)
Edward S. Bender, Val J. Kelmeckis, SP5, Paul F. Robinson, Daniel D. Rieder, SP5, Robert J. Donald, SP4, Melvin W. Moore, SP6

8. CONTRACT OR GRANT NUMBER(s)

9. PERFORMING ORGANIZATION NAME AND ADDRESS
Director, Chemical Systems Laboratory
Attn: DRDAR-CLT-E
Aberdeen Proving Ground, Maryland 21010

10. PROGRAM ELEMENT, PROJECT, TASK AREA & WORK UNIT NUMBERS
Task 2, Subproject 3,
PAA Project 57X4114

11. CONTROLLING OFFICE NAME AND ADDRESS
Director, Chemical Systems Laboratory
Attn: DRDAR-CLJ-I
Aberdeen Proving Ground, Maryland 21010

11

12. REPORT DATE
August 1977

13. NUMBER OF PAGES
90

14. MONITORING AGENCY NAME & ADDRESS (if different from Controlling Office)

12 93p.

15. SECURITY CLASS. (of this report)
UNCLASSIFIED

15a. DECLASSIFICATION/DOWNGRADING SCHEDULE
NA

16. DISTRIBUTION STATEMENT (of this Report)

Approved for public release; distribution unlimited.

17. DISTRIBUTION STATEMENT (of the abstract entered in Block 20, if different from Report)

18. SUPPLEMENTARY NOTES

Development of methods to minimize environmental contamination

Ecological surveys of environmental conditions at AMC installations

19. KEY WORDS (Continue on reverse side if necessary and identify by block number)

Environmental survey	Industrial discharges
Fauna and flora	Volunteer Army Ammunition Plant (VAAP)
Air quality	TNT
Water quality	Munitions manufacturing

20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

A preliminary environmental survey was conducted at Volunteer Army Ammunition Plant (VAAP) from 22 to 29 March 1976. This report includes (1) a presentation of the data compiled from that visit and a thorough literature search of regional sources and (2) a discussion of the actual or potential environmental impact of operations performed at VAAP. Biological data gaps have been indicated and the potential occurrences of rare or endangered species have been discussed and documented where this information is available.

PREFACE

The work described in this report was authorized under Task 2, Subproject 3, PAA Project 57X4114, Development of Methods to Minimize Environmental Contamination; Ecological Surveys of Environmental Conditions at USAMC (now DARCOM) installations.

In conducting such ecological surveys, a three-phase program has been developed. Phase I (initial site visit) was completed in March 1976. The publication of this report completes phase II of this program. The design of phase III (ecological surveys) will be based on the results of this report, although phase III work will not be conducted at Volunteer Army Ammunition Plant (VAAP) under this program.

The use of trade names in this report does not constitute an official endorsement or approval of the use of such commercial hardware or software. This report may not be cited for purposes of advertisement.

Acknowledgments

The authors wish to express their thanks to Mr. James Fry (VAAP) and Mr. Edward Bingham (ICI-US, Inc.) and to their staff for their cooperation and assistance in gathering data pertinent to VAAP.

Special thanks are also given to Mrs. Jane Dierdorff for preparing the artwork, to Dr. F. Prescott Ward for proofreading the paper, and to Mrs. Phyllis Schultz for typing the draft manuscript.

CONTENTS

CONTENTS (Contd)

LIST OF FIGURES

CONTENTS (Contd)

LIST OF TABLES

CONTENTS (Contd)

PRELIMINARY ENVIRONMENTAL SURVEY OF VOLUNTEER ARMY AMMUNITION PLANT, TYNER, TENNESSEE, MARCH 1976

I. INTRODUCTION.

In response to public concern for environmental quality, the President of the United States, the Congress, and State and local legislative bodies have issued stringent directives to ameliorate the declining health of the environment. In response to these directives, the US Army Materiel Development and Readiness Command (DARCOM) has initiated major programs in pollution control and abatement which involve many scientific disciplines, including biological sciences. As a consequence, biological assessments of pollution control and abatement are now being used to insure that the environment is not being deleteriously affected.

In conducting assessments at the direction of DARCOM, personnel from Ecological Research, Demilitarization/Disposal Office, Edgewood Arsenal, Aberdeen Proving Ground, Maryland 21010, have developed a three-phase approach: (I) initial site survey, (II) preliminary environmental survey, and (III) ecological surveys. The objectives of this publication are to collate and to evaluate data pertaining to the area in which Volunteer Army Ammunition Plant (VAAP) is located, the mission and activities of the installation, an environmental description of the installation, and potential environmental impacts from installation-related activities. This document provides a basis for determining the critical activities at VAAP which are now affecting environmental quality. Current information is evaluated and recommendations for additional work are made in areas where the existing information is incomplete or insufficient to determine the impact of particular activities on the biota and the environment of VAAP. This document also provides a detailed list of references and other sources from which specific detailed information can be obtained. This survey program was initiated at VAAP on 1 March 1976. Phases I and II will be completed with this report. Plans to initiate ecological surveys at VAAP will not be developed until work is completed by US Army Medical Research and Development Command, Fort Detrick, Maryland; however, recommendations for surveys in specific areas are included.

II. AREA DESCRIPTION.

A. General.

Volunteer Army Ammunition Plant is located in the southeast corner of the state of Tennessee, Hamilton County, on Tennessee Highway 2-A (figure 1), about 13-1/2 highway miles northeast of the center of Chattanooga. Less than 1/2 mile of the plant is bordered by the corporate city limits. Table 1 lists the counties with their areas and population within a 30-mile radius of the installation.[1] This circle includes three states and the principal area from which plant employees commute. Chattanooga is a very old city which has become a center for transportation and industry in the southeastern United States.

B. Topography and Drainage.

Volunteer Army Ammunition Plant is located in the southern portion of the Great Valley of Tennessee, an area of the Tennessee River between the Cumberland Mountains to the west and the Appalachian Mountains to the east, which extends northeast from Alabama across

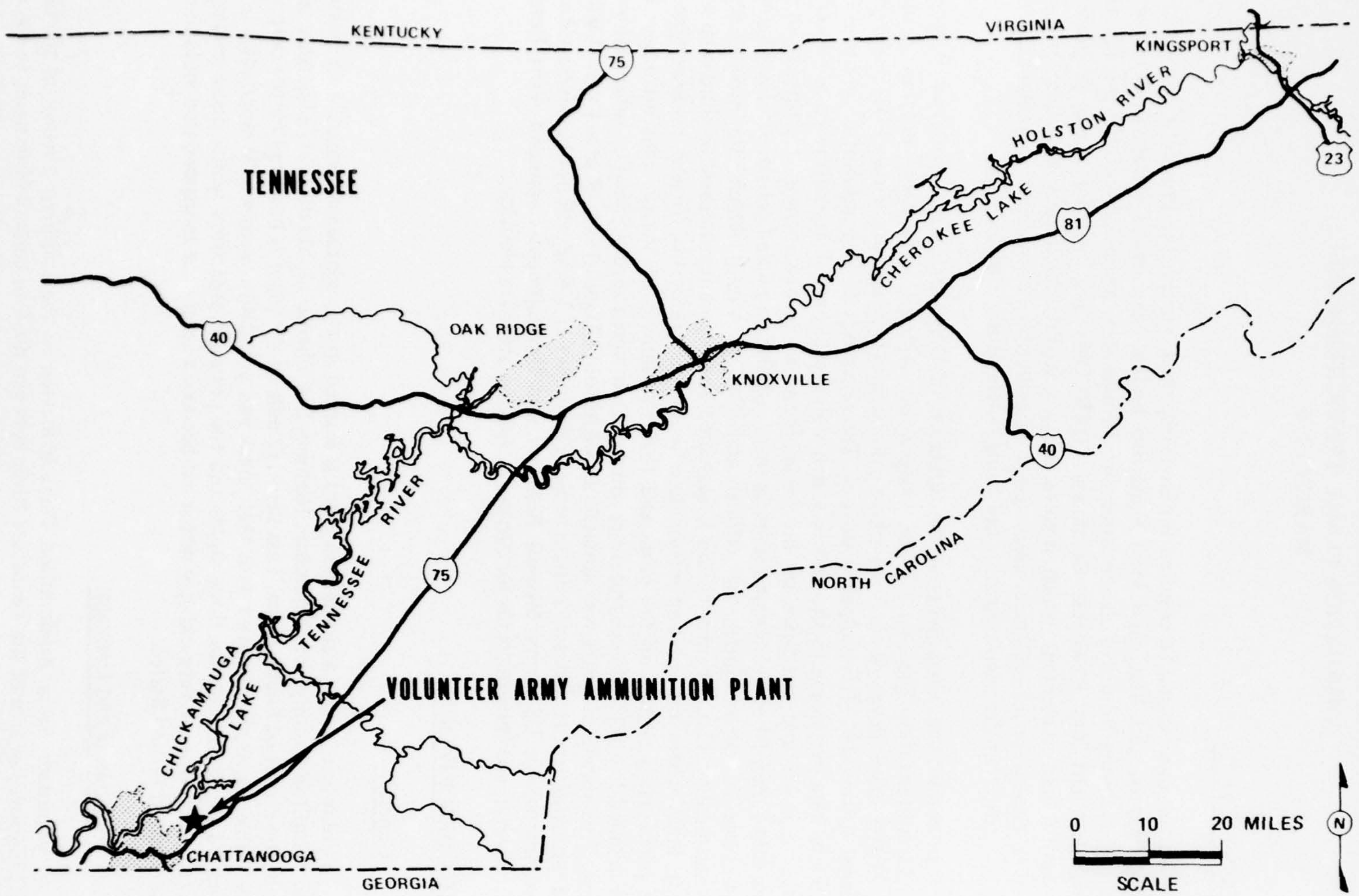


Figure 1. Location of Volunteer Army Ammunition Plant, Tyner, Tennessee

Table 1. Size and Population of the Major Counties Within a 30-Mile Radius of Volunteer Army Ammunition Plant, Tyner, Tennessee

County	Area	Population	County Seat
	sq mi		
Tennessee			
Hamilton	550	255,077	Chattanooga
Bradley	334	50,686	Cleveland
Sequatchie	273	6,331	Dunlap
Marion	506	20,577	Jasper
Rhea	312	17,202	Dayton
Meigs	191	5,219	Decatur
McMinn	432	35,462	Athens
Georgia			
Walker	445	50,691	LaFayette
Whitfield	281	55,108	Dalton
Catoosa	167	28,271	Ringgold
Alabama			
Jackson	1,079	39,202	Scottsboro

Tennessee in a series of parallel ridges with intervening flat valleys. The Cumberland escarpment forms the western horizon of the valley of the Tennessee River, rising 1,000 to 1,500 feet above the valley floor.[1] Eighteen miles southeast across several lesser ridges, the White Oak Range rises 600 to 900 feet to form the eastern rim of the valley. The Tennessee River meanders southwesterly from Chickamauga Lake to the base of Lookout Mountain and then loops north through the escarpment into another valley. The Tennessee River and its tributaries form the major drainage basin of the Chattanooga area. In 1940, the river was impounded above Chattanooga, at river mile 471.0, by the construction of Chickamauga Dam. The Chickamauga Reservoir extends 58.9 miles upstream to the Watts Bar Dam. The total drainage area above Chickamauga Dam is 20,790 square miles and the water surface area is 34,500 acres (54 square miles). Prior to impoundment, the 7-day, 10-year flow was 6,000 ft^3/s but now it is 13,600 ft^3/s. The long-term mean flow (28 years) of the principal local tributary, the Hiwassee River, was 4,600 ft^3/s at Charleston, Tennessee (7-day, 10-year low flow between 1920 and 1943, 600 and 1,300 ft^3/s after impoundment).[2]

The drainage from many small creeks throughout the impoundment forms small lakes and coves within Chickamauga Lake. Harrison Bay, north of VAAP, receives drainage from Waconda Bay, Wolftever Creek, Varnall Creek, Long Savannah Creek, and Rogers Branch. These drainages form a major portion of the water in Harrison Bay State Park. There are no US Geological Survey gauging stations on any of these drainages. Below Chickamauga Dam, the north and south Chickamauga Creeks enter the Nickajack Reservoir. The dams provide hydroelectric power and flood control. The impoundments are sources of recreation, industry, and domestic water supplies for the inhabitants of the Chattanooga vicinity.

C. Climate.

The climate of VAAP area is moderate, characterized by cool winters and quite warm summers (table 2).[3] The sheltering effect of the Cumberland Mountains causes winter temperature to average about 3°F warmer than that of other locations on the southern Cumberland Plateau in the State. In winter, the mountains moderate temperatures by retarding the flow of cold air from the north and the west. Winter weather is changeable and alternates between cool spells, with an occasional cold period. Extreme cold weather is rare. Temperatures fall as low as the freezing point on over half of the winter days. Temperatures have fallen below zero only 13 times since 1879. Snowfall varies from year to year. Heavy snowfalls (3 inches or more) generally last for only a few days. Ice storms bringing freezing rain or glaze ice are more common; occasionally, severe mid-winter icing impairs transportation and causes damage to property and vegetation. Summer temperatures range into the high 80's and 90's with comparable relative humidities. Most afternoon temperatures are modified by thunderstorms during which temperatures frequently drop 10° to 15°F within minutes. Precipitation is well distributed throughout the year, with the greatest amounts occurring in the winter (table 3) when cyclonic storms from the Gulf of Mexico reach the area. A second peak rainfall period generally occurs in July, principally from the thundershowers that move into the area from the south and the southwest. Rainfalls with 1.5 inches, or more, in 1 hour are expected once every 2 years. The growing season averages 228 days, with the first frost occurring between 27 October and 9 November, and the last freezing temperature occurring in the spring between 26 March and 12 April. The average windspeed is 6.1 mph, but the wind is calm nearly one quarter of the time. Prevailing winds tend to parallel the valley. As a result, this southern Appalachian region has the highest frequency of temperature inversions of sites below 500 feet in elevation east of the Mississippi. The topography of this region contributes to the average weather conditions (i.e., wind direction, air temperature, and relative humidity) that are particularly unfavorable for the dispersion of air pollutants. Low-level inversions occur 30% to 50% of the time in the Chattanooga vicinity.

Table 2. Average Temperature for the Chattanooga, Tennessee Area

(Normals are based on records for 1941-1970 period.)

Month	Daily maximum	Daily minimum	Monthly
	°F	°F	°F
January	49.9	30.5	40.2
February	53.4	32.3	42.9
March	61.2	38.4	49.8
April	72.9	48.1	60.5
May	81.0	56.0	68.5
June	87.5	64.5	76.0
July	89.5	68.1	78.8
August	89.0	67.0	78.0
September	83.4	60.4	71.9
October	73.5	48.1	60.8
November	60.7	37.1	48.9
December	50.9	31.4	41.2
Yearly average	71.1	48.5	59.8

Table 3. Monthly Precipitation in Inches (Average) for the Chattanooga, Tennessee Area

(Amounts are based on records for the 1941-1970 period.)

Month	Water equivalent							Snow; ice pellets			
	Normal	Maximum monthly	Year	Minimum monthly	Year	Maximum in 24 hours	Year	Maximum monthly	Year	Maximum in 24 hours	Year
January	5.38	12.28	1947	1.13	1961	4.44	1949	8.4	1966	8.0	1966
February	5.19	11.03	1944	.62	1941	3.93	1958	10.4	1960	8.7	1960
March	5.63	13.80	1973	1.17	1967	6.53	1973	10.1	1960	6.0	1960
April	4.42	11.92	1964	.44	1942	3.07	1944	1.0	1971	1.0	1971
May	3.43	6.65	1946	.54	1941	3.46	1964	T	1944	T	1944
June	3.68	9.40	1949	.87	1968	4.85	1949	0.0	–	0.0	–
July	5.14	11.54	1941	.20	1957	4.79	1941	0.0	–	0.0	–
August	3.22	6.20	1969	.56	1963	3.70	1941	0.0	–	0.0	–
September	3.69	12.19	1957	.34	1941	4.35	1957	0.0	–	0.0	–
October	2.95	9.91	1949	.24	1963	2.94	1949	T	1954	T	1954
November	3.94	13.59	1948	.93	1953	4.56	1948	2.8	1950	2.8	1950
December	5.25	13.68	1961	.86	1965	5.[illegible]	1942	9.1	1963	8.9	1963
Yearly average	51.92	13.80	March 1973	.20	July 1957	6.53	March 1973	10.4	February 1960	8.9	December 1963

D. Air Quality.

In eastern Tennessee, in contrast to the rest of the State, the windspeed is lower, stable conditions in the lower atmosphere are common, the frequency of fog is higher, and there are large valleys in which air circulation is limited. In order to examine the hourly changes in air temperature at different elevations, continuous measurements of temperature differences between two sites (870 and 720 feet elevations) were made in March 1968[4] at Farmers' Chemical Association, Inc. (FCAI) a lessee at VAAP. The overlying airmass was at least 1° warmer at the higher elevation for a 13-hour period from sunset to 2 hours after sunrise. Rapid industrial growth in the Chattanooga area has caused severe air-pollution problems which are aggravated by the topography and climate of the region. The Chattanooga-Hamilton County Air Pollution Control Board, stimulated by public complaints, has promulgated stringent regulations to control particulates and opacity.[5,6] The State pollution control board reports that the number of monitoring stations violating the secondary and primary ambient standards for the annual geometric means and/or the 24-hour suspended particulate concentrations (60 and 75 $\mu g/m^3$, respectively) from January 1971 through June 1975 have decreased significantly[5-8] as a result of their surveillance programs. The ambient standards for the annual arithmetic means of nitrogen dioxide (0.05 ppm) and opacity (percent) are consistently violated in the Chattanooga area as a result of manufacturing, coal burning emissions, and automobile exhausts. The ambient conditions in the vicinity of VAAP are severe since the plant is a major local source for NO_2 acid mist. In 1968, the Public Health Service inventoried air emission sources and their quantities in the Chattanooga vicinity. The data for Hamilton County, including that of VAAP, have been summarized and graphed (figure 2). Group 4 represents manufacturing facilities such as VAAP.[8] At that time particulates were emitted from the redwater incinerator and at FCAI powerhouse No. 1 (building 401-1). Two additional categories were measured but are not shown: (1) methane, which in Hamilton County is insignificant, and (2) sulfuric acid mist, estimated at 8.9 tons per year, all of which is produced by VAAP. In all other categories, manufacturing emissions provide a significant contribution to the pollution loading in the atmosphere. The Chattanooga-Hamilton County Air Pollution Control Board conducts monitoring for total suspended solids, sulfur dioxide, and nitrogen oxides at most of Hamilaton County's 12 monitoring stations, and data have been selected from eight stations (figure 3). These ambient data for 1974 have been summarized for eight stations in the Chattanooga vicinity (table 4). Station 4, Silverdale Fire Tower, is the most directly influenced of all the stations by the emissions from VAAP. Data from this station indicate that there is an occasional problem with total suspended particulate concentrations. The primary standard was exceeded here twice during 1974. During the 1968 area-wide study of Chattanooga and Rossville, the maximum ambient concentrations of suspended particulates were centered in downtown Chattanooga and at VAAP. The maximum observed concentrations were observed at the National Guard Armory (697 $\mu g/m^3$) and at VAAP (586 $\mu g/m^3$). The 1968 particulate level at VAAP was a result of coal burning at FCAI and the redwater incinerator. These levels were sufficient to cause adverse health effects.[4] However, these particulate levels have declined steadily since 1968, mainly for two reasons: (1) The Chattanooga-Hamilton County Air Pollution Control Board has aggressively enforced the county's standards for particulate emissions and opacity of the stack emissions and (2) FCAI converted their boiler plant from coal burning to fuel oil and natural gas shortly after the 1968 survey. Hourly high concentrations of nitrogen oxides (NO_x) were found up to 3.8 ppm (with a daily high maximum of 1.0 ppm of NO_x) in the vicinity of VAAP east of Missionary Ridge. NO_x is responsible for photochemical fogs which also can cause chronic respiratory ailments. Although sulfur dioxide levels were low during this survey, recent malfunctions of the sulfuric acid regeneration unit at VAAP allowed us to observe the release of an acid mist fog which created traffic hazards by reducing visibility along route 58 north of the plant. In 1970, a study was conducted in

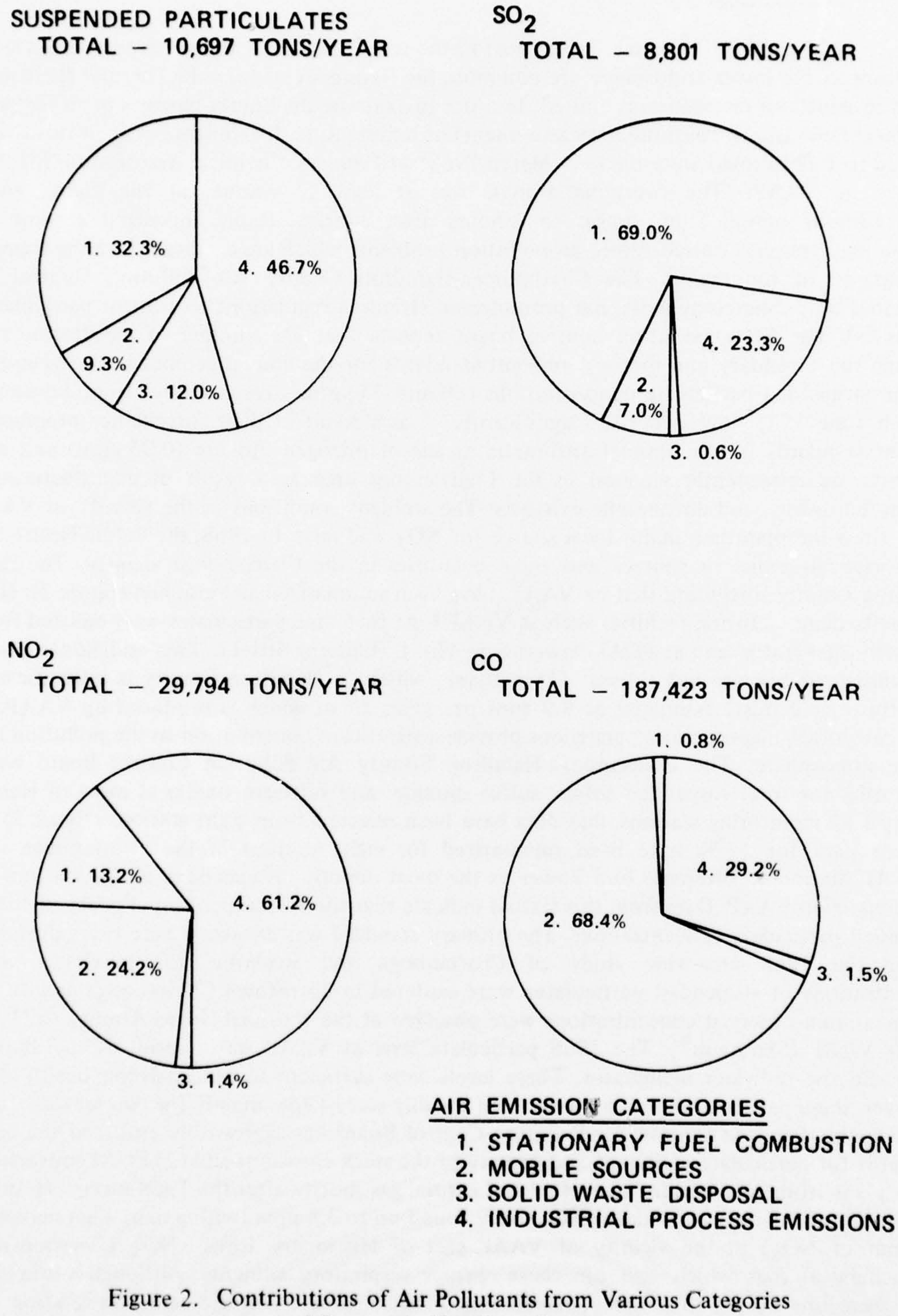


Figure 2. Contributions of Air Pollutants from Various Categories of Sources in Hamilton County

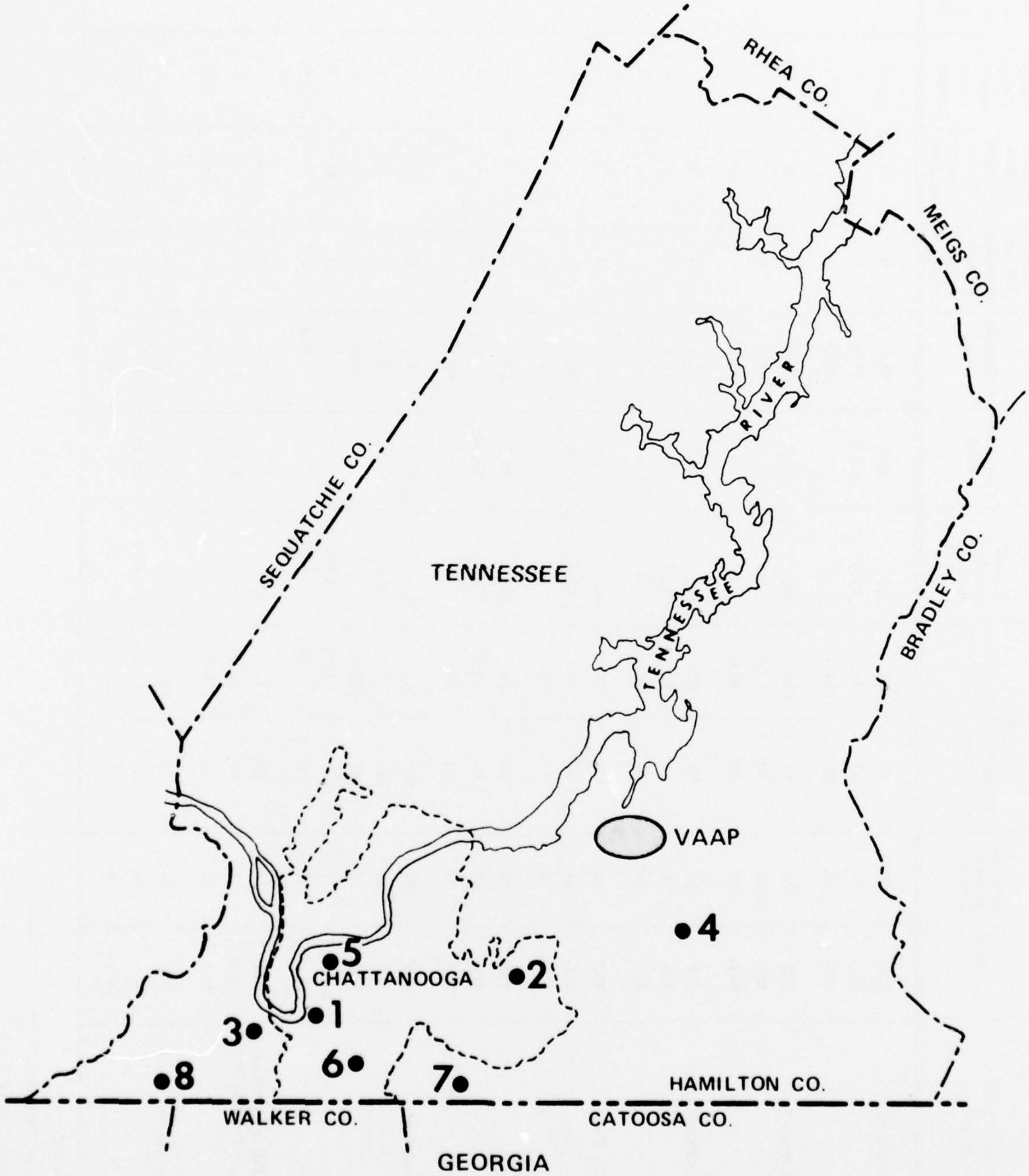


Figure 3. Location of Air-Sampling Sites in Chattanooga and in Hamilton County

Table 4. Ambient Air Quality Monitoring Data from Hamilton County Health Department - 1974

Map number and location[a]	Parameter	Sampling interval in hours	Number of observations	Maximum observed	Second maximum observed	Geometric *mean*	Arithmetic *mean*	Number of times exceeding 24-hour primary standard	Number of times exceeding 24-hour secondary standard	Number of times[b] exceeding 1-hour standard	Number of times[c] exceeding 3-hour standard
South Broad Street	TSP	24	59	166	163	68.9	78.0	0	3	–	–
	SO_2	24	57	46.0	45.0	13.30	14.02	0	–	–	–
	NO_2	24	55	124.0	–	–	37.58	–	–	–	–
Lovell Field Airport	TSP	24	58	434	280	69.0	88.5	3	10	–	–
	SO_2	24	59	12.5	12.5	12.5	12.5	0	–	–	–
	NO_2	24	60	86.0	–	–	43.15	–	–	–	–
Lookout Mountain Incline	TSP	24	58	90	81	34.2	39.6	0	0	–	–
	SO_2	24	51	12.5	12.5	12.5	12.5	0	–	–	–
	NO_2	24	49	29.0	–	–	15.23	–	–	–	–
Silverdale Fire Tower	TSP	24	61	179	161	70.9	80.1	0	2	–	–
	SO_2	24	56	12.5	12.5	12.5	12.5	0	–	–	–
	NO_2	24	57	78.0	–	–	42.11	–	–	–	–
City Hall	TSP	24	53	159	148	76.2	83.6	0	1	–	–
	SO_2	24	45	60.0	50.0	14.04	15.57	0	–	–	–
	NO_2	24	45	81.0	–	–	48.19	–	–	–	–
Rossville Boulevard	TSP	24	362	242	216	83.9	93.4	0	30	–	–
	SO_2	24	345	74.0	50.0	12.90	13.32	0	–	–	–
	NO_2	24	348	104.0	–	–	43.63	–	–	–	–
	Soiling	2	2101	5.98	4.85	–	–	21	53	12	57
	Ozone	1	2190	.167	.158	–	.034	–	–	126	–
East Ridge Police Department *(Chattanooga) Tomleas Drive*	TSP	24	54	131	127	46.5	52.4	0	0	–	–
	SO_2	24	54	50.0	12.5	12.83	13.19	–	–	–	–
	NO_2	24	54	70.0	–	–	32.39	–	–	–	–
I-24 Welcome Center	TSP	24	38	115	115	46.8	52.3	0	0	–	–
	SO_2	24	49	34.0	28.0	13.16	13.53	0	–	–	–
	NO_2	24	48	81.0	–	–	43.20	–	–	–	–

[a] Shown on figure 3.

[b] Times exceeding 2-hour primary standard for soiling data.

[c] Times exceeding 2-hour secondary standard for soiling data.

Chattanooga among parents of high-school students to determine the incidence of chronic respiratory problems.[9] Parents living in an area of high nitrogen dioxide concentration north of VAAP had a significantly lower forced respiratory volume which implied that some lung impairment might have resulted from exposure to high NO_x concentrations. The area selected for the control subjects was not well isolated from other air contaminants, hence no firm conclusion could be drawn. This was the second study in the Chattanooga area; the first study examined grammar-school children. Unfortunately, no further studies were conducted.

E. Water Quality.

Water quality in the Tennessee River is generally suitable for recreation, drinking, fish and wildlife propagation, and industrial uses. The central basin of Lake Chickamauga has low solids and few dissolved minerals although the water is somewhat hard.[10] Industrial and domestic wastes enter the lake from the Hiwassee River (figure 4) although the waste volume of the river is considered to be diluted ("assimilated") by the Tennessee River. In the lower lake near VAAP, there is also pollution from marine toilets. This problem is being controlled through the use of approved disinfection units and holding tanks for on-shore disposal. The Hiwassee River formerly carried high biochemical oxygen demand (BOD) loads from domestic sewage into the Chickamauga Lake; recently, however, sewage treatment facilities have been improved so that waste loading has been reduced steadily since 1970. There are still many significant industrial discharges entering the drainages from the Chattanooga-Harrison area (figure 4). Friar Branch receives wastewaters containing ammonia and nitrate from GAF Corporation and FCAI. Although the Environmental Protection Agency (EPA) did not find the waters to be toxic to fish in static bioassays,[11] FCAI has since upgraded its treatment so that pH and nitrogenous ammonia levels are becoming so low that most process water will be recycled. Further downstream, Friar Branch converges with South Chickamauga Creek, which receives toxic effluents from Alco Chemical Corporation, Mueller Company, W. R. Grace Chemical Company, and the North Hawthorne Street Dump. Despite the numerous industrial outfalls, the EPA considers the creek to be a relatively good, warm-water fishing area because of the creek's large dilution volume.[11] The creek is slow moving but never anoxic. When comparing the creek's water quality to that of Citico Creek which is severely polluted with organics and BOD from the Southern Railway activities, the EPA found that BOD, chemical oxygen demand (COD), and coliforms were lower in the South Chickamauga Creek. Both of these creeks enter the Nickajack Reservoir.

The waters of Chickamauga Lake are characterized by high silica, high conductivity, and chlorine. The high silica concentrations cause scaling and pitting problems in steam-generating boilers. These problems are avoided by frequent purging and continuous boiler blowdown. The water temperature of Chickamauga Lake varies seasonally, and temperature differences create stratification. The relative temperature difference between the inflowing water from a tributary and the receiving pool can control mixing and reaeration of the two water masses. Thermal stratification can prevent reaeration of the water flowing into the lake. For example, in the summer, water with a high organic content emanating from the Hiwassee River essentially remains anoxic and unmixed with the main water mass of Lake Chickamauga. Because mixing does not always occur, a waste stream can cause a severe impact on water quality conditions and aquatic life even though its presence would be unnoticed if complete mixing occurred. The nitrogen content of the water from Harrison and Waconda Bays is low except during periods of trinitrotoluene (TNT) production. The water quality of Waconda Bay is directly influenced by production levels and manufacturing discharges at VAAP.[12] Fish kills investigated in the Waconda Bay were traced to acid spills and releases of wastewaters contaminated with pinkwater (nitrobodies).

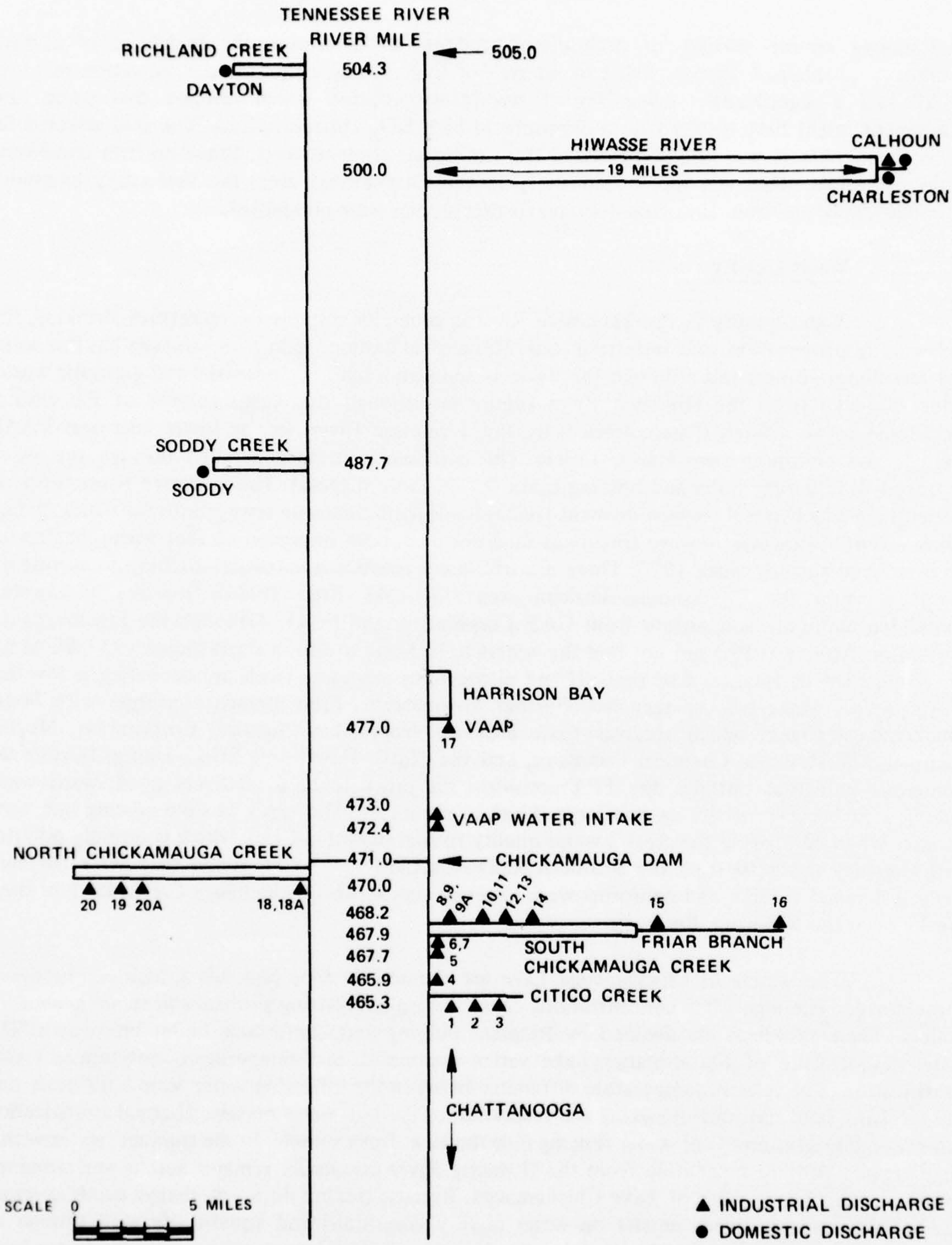


Figure 4. Domestic and Industrial Effluents in the Tennessee River Basin Near the Volunteer Army Ammunition Plant

The horizontal branch graphs represent upstream miles in the creeks to the discharge. Station numbers are identified on table 5.

Downstream from VAAP, discharges from several industries (described in section III.C. Topography and Drainage) degrade the water quality of the Friar Branch. Water quality has improved in the Waconda Bay as a result of reduced production levels and gradually improved treatment of TNT wastewaters. As the result of litigation, continuing scrutiny by the Water Quality Division of Tennessee Department of Public Health and the EPA, major dischargers on South Chickamauga Creek (table 5) and downstream of VAAP have implemented wastewater treatment to remove detrimental components of their effluents. The water quality of Chickamauga Reservoir is superior to that of the Nickajack Reservoir (table 5) because there is less organic loading upstream from Chattanooga.

Lake Chickamauga is affected by discharges from several domestic sewage treatment plants of the cities upstream of VAAP. There are additional industries upstream from Charleston, on the Hiwassee River, but the specific chemical quality of their effluents was not located through STORET or other enforcement sources. A combination of reduced munitions production and improved effluent treatment have lead to a general improvement in water quality in Chickamauga Lake and its tributaries. Additional water quality data are attached to show variations in the Tennessee River, the North Chickamauga Creek, and the South Chickamauga Creek (tables 6 through 8).

Sediments in Waconda Bay and Nickajack Lake have been analyzed for nutrients[12,13] and heavy metals.[10] Recent work shows that there are higher levels of phosphorus, nitrogen, and organic material in the sediments of the upper bay than in lower Chickamauga Lake. The source of this material has not been identified.

III. INSTALLATION.

A. Location and Size.

Volunteer Army Ammunition Plant is situated in Hamilton County, Tennessee. The main entrance, at the intersection of State Highway 2-A and Hickory Valley Road, is approximately 13 miles northeast of the center of Chattanooga. The city limits of Chattanooga join a portion of the plant boundary.[14]

The total area of VAAP is 7,297 acres. About 25% (1,726 acres) of this is occupied by the production and storage areas, whereas the remaining 5,571 acres are forested.

B. History.

The VAAP was constructed in 1941 by the Corps of Engineers as a Government Owned, Contractor Operated (GOCO) facility for the purpose of supplying TNT during World War II and, ever since, it has been maintained on a standby basis with intermittent periods of reactivation. The original construction contract was awarded to Hercules Powder Company of Wilmington, Delaware, on 1 August 1941. This company served as design consultant and was later the operator. The original project called for 12 lines with support facilities to be constructed on 5,975 acres of land. Later, four more TNT lines were added, but they were not used in World War II. They were operated during the Korean War.

Table 5. Waste Characteristics of Principal Industrial Discharges in the Tennessee River Basin Near the Volunteer Army Ammunition Plant

Number	Facility	Source	Major pollutants
1	Southern Railway	Wash down	Oil and grease (90 mg/l)
2	Southern Railway	Yard and car washing drainage	BOD_5 (30 to 50 mg/l); coliform; low
3	Southern Railway	Yard drainage	Dissolved oxygen (DO)
4	Amnicola Dump	Decomposition, runoff	High fecal coliform; fenchrome camphor; fenchyl alcohol
5	Seaboard Allied Mining	Concentrated untreated waste	Coliform, BOD_5 (1675 lb/day)
6	Central Soya	Main outfall	Oil and grease (53 mg/l); BOD_5 (142 lb/day)
7	Central Soya	Oil skimmer	Phosphorus (20 to 70 mg/l); coliform
8	Alco Chemical Company	Process waste	Zinc (70 mg/l); dissolved solids
9	Alco Chemical Company	Cooling water	(15,000 mg/l); suspended solids
9A	Alco Chemical Company	Old sedimentation pond	(346 mg/l); total organic carbon (53 mg/l)
10	Mueller Company	Industrial waste	Phenol – highly variable
11	Mueller Company	Domestic waste	BOD
12	W. R. Grace & Company	Settling pond	High pH; phosphorus (220 lb/day)
13	W. R. Grace & Company	Dump leachate	Possible radioactive waste; iron, manganese
14	North Hawthorne Street Dump	Leachate	Ammonia (385 mg/l); dissolved
15	GAF Corporation	Effluent	BOD_5 (83 lb/day); NH_4 (340 mg/l); solids (3600 mg/l)
16	FCAI	Effluent	Nitrogen (2,000 lb/day); 720 lb/day NH_4
17	VAAP	Munitions wastewater	Nitrogen (2,150 lb/day); BOD_5 (1,640 lb/day); solids
18	Du Pont	Effluent	BOD_5 (1,550 lb/day); oil and grease (720 lb/day)
18A	Du Pont	Water intake	Ammonia
19	Hills Hosiery Mill	Effluent	BOD_5
20	Tennessee Finishing & Dyeing	Effluent	Untreated wastes; low DO
20A	Tennessee Finishing & Dyeing	Domestic waste	BOD_5 (80 mg/l); chromium

Table 6. Water Quality Data from Chickamauga Lake, Tennessee River (Mile 472.80)

(All data were taken from STORET on 21 January 1976.)

Parameter	Units	Number of observations	Mean	Variance	Standard deviation	Maximum	Minimum
Water temperature	°C	211	17.36	36.72	6.05	26.10	6.40
Conductivity at 25°C	Micromhos	33	170.90	589.79	24.28	200.00	140.00
Dissolved oxygen	mg/l	211	8.15	3.61	1.90	12.10	4.40
pH		48	7.52	.36	.60	8.60	6.80
Total alkalinity, $CaCO_3$	mg/l	5	51.40	.80	.89	52.00	50.00
Arsenic,* dry wt	mg/kg	1	13.00			13.00	13.00
Barium,* dry wt	mg/kg	1	160.00			160.00	160.00
Beryllium,* dry wt	mg/kg	1	3.00			3.00	3.00
Cadmium,* dry wt	mg/kg	1	7.50			7.50	7.50
Chromium,* dry wt	mg/kg	1	76.00			76.00	76.00
Chromium, total	μg/l	11	18.36	416.45	20.40	50.00	5.00
Cobalt, dry wt	mg/kg	1	33.00			33.00	3.00
Copper, total	μg/l	11	13.63	5.45	9.244	40.00	10.00
Copper,* dry wt	mg/kg	1	47.00			47.00	47.00
Iron, total	μg/l	11	426.36	25,305.7	159.07	750.00	230.00
Lead,* dry wt	mg/kg	1	99.00			99.00	99.00
Manganese,* dry wt	mg/kg	1	3,900.00			3,900.00	3,900.00
Manganese	μg/l	7	71.42	414.29	20.35	100.00	40.00
Molybdnum,* dry wt	mg/kg	1	6.00			6.00	6.00
Nickel, total	μg/l	11	50.00	.00	.00	50.00	0.00
Nickel,* dry wt	mg/kg	1	57.00			57.00	57.00
Silver,* dry wt	mg/kg	1	4.00			4.00	4.00
Strontium,* dry wt	mg/kg	1	2.90			2.90	2.90
Zinc, total	μg/l	11	39.09	449.09	21.19	90.00	20.00
Zinc,* dry wt	mg/kg	1	700.00			700.00	700.00
Antimony*						6.00	6.00
Tin, dry wt	mg/kg	1	59.00			59.00	59.00
Aluminum,* dry wt	mg/kg	1	41,000.0			41,000.0	41,000.0
Selenium,* dry wt	mg/kg	1	1.00			1.00	1.00
Titanium,* dry wt	mg/kg	1	2,400.00			2,400.00	2,400.00
Iron,* dry wt	mg/kg	1	39,000.00			39,000.0	39,000.0
Mercury,* dry wt	mg/kg	1	3.40			3.40	3.40

*Sediment samples in which concentrations are mg/kg dry of sediment.

Table 7. **Water Quality Data**, North Chickamauga Creek (Mile 0.3), 1975

(All data were taken from *STORET* on 21 *January* 1976.)

Parameter	Units	Number of observations	Mean	Variance	Standard deviation	Maximum	Minimum
Water temperature	°C	3	14.46	10.8036	3.28	18.000	11.50
Turbidity	JTU	3	3.50	2.29	1.51	4.70	1.80
Color	Units	3	6.00	13.00	3.60	10.00	3.00
AP color	Units	3	11.00	43.00	6.55	18.00	5.00
Conductivity at 25°C	Microohms	3	104.66	180.35	13.42	120.00	95.00
Dissolved oxygen	mg/l	3	9.13	.37	.61	9.80	8.60
Biochemical oxygen demand	mg/l	3	1.00	.00	.00	1.00	1.00
Chemical oxygen demand	mg/l	3	2.66	1.33	1.15	4.00	2.00
Total pH	SU	3	7.40	.12	.34	7.80	7.20
Total alkalinity	mg/l	3	40.66	97.33	9.86	52.00	34.00
Residue, total	mg/l	3	4.66	8.33	2.88	8.00	3.00
Organic nitrogen	mg/l	3	.06	.00	.04	.10	.02
Ammonia nitrogen, total	mg/l	3	.02		.00	.02	.02
Nitrogen, total	mg/l	3	.32	.00	.04	.37	.28
Phosphate, total	mg/l P	3	.02	.00	.01	.03	.01
Phosphate, dissolved	mg/l P	2	.01		.00	.01	.01
Total hardness carbonate	mg/l	3	44.33	297.33	17.24	63.00	29.00
Calcium, total	mg/l	3	13.33	37.33	6.11	20.00	8.00
Magnesium, total	mg/l	3	2.70	.20	.45	3.20	2.30
Sodium, total	mg/l	3	1.40	.01	.09	1.50	1.30
Potassium, total	mg/l	3	.63	.00	.05	.70	.60
Chloride	mg/l	3	3.66	.33	.57	4.00	3.00
Sulfate, total	mg/l	3	10.66	9.33	3.05	14.00	8.00
Fluoride, total	mg/l	2	.10		.00	.10	.10
Silica, dissolved	mg/l	3	5.26	.30	.55	5.90	4.90
Iron, total	μg/l	3	293.33	18233.4	135.03	430.00	160.00
Iron, dissolved	μg/l	2	60.00	200.00	14.14	70.00	50.00
Ferrous iron	μg/l	1	75.00			75.00	75.00
Manganese, total	μg/l	3	63.33	633.33	25.16	90.00	40.00
Manganese, dissolved	μg/l	2	45.00	50.00	7.07	50.00	40.00
Total coliform	μg/100 ml	2	105.00	18050.0	134.35	200.00	10.00
Fecal coliform	μg/100 ml	3	86.66	6433.34	80.20	170.00	10.00
Residue, dissolved	mg/l	3	76.66	233.33	15.27	90.00	60.00
Mud, dry wt	mg/kg	1	.10			.10	.10

Table 8. Water Quality Data from South Chickamauga Creek (Mile 1.4), 1972

(All data were taken from STORET on 21 January 1976.)

Parameter	Units	Number of observations	Mean	Standard deviation	Maximum	Minimum
Water temperature	°C	5	21.30	.458	22.00	21.00
Flow rate	Instantaneous gal/min	5	16,000.	6,820.	27,000.	10,000.
Biochemical oxygen demand, 5-day	mg/l	4	60.00	43.97	110.00	10.00
pH	SU	5	6.94	.92	8.10	5.90
Laboratory, pH	SU	5	7.62	.30	8.10	7.40
Total alkalinity, $CACO_3$	mg/l	5	2,758.00	1,446.31	5,100.00	1,150.00
Total acidity, $CACO_3$	mg/l	5	275.80	201.99	480.00	.00
Residue, total	mg/l	5	3,763.40	747.78	4,671.00	2,633.00
Residue, dissolved	mg/l	5	3,721.00	757.62	4,633.00	2,581.00
Residue, total nonfilterable	mg/l	5	42.40	26.52	83.00	18.00
Oil-grease, total	mg/l	1	20.00		20.00	20.00
NH_3-N, total	mg/l	5	279.80	117.08	385.00	114.00
Total Kjeldahl, nitrogen	mg/l	5	305.40	90.56	385.00	157.00
NO_2 and NO_3, N-total	mg/l	5	11.87	15.66	35.50	.18
Phosphate, total	mg/l P	5	.86	.19	1.00	.53
Total organic carbon, C	mg/l	5	316.00	90.09	410.00	180.00
Arsenic, total	μg/l	5	5.00	.00	5.00	5.00
Chromium, total	μg/l	5	144.00	42.19	200.00	90.00
Copper, total	μg/l	5	56.80	5.40	65.00	50.00
Iron, total	μg/l	5	12,050.00	4,668.37	15,250.00	4,500.00
Lead, total	μg/l	5	147.00	49.19	205.00	100.00
Manganese	μg/l	5	815.00	88.39	955.00	710.00
Zinc, total	μg/l	5	363.00	66.20	415.00	250.00
Total coliform	μg/100 ml	5	10,684.00	96,851.40	240,000.00	2,200.00
Fecal coliform	μg/100 ml	5	4,680.00	7,118.42	17,000.00	200.00
Phenols, total	μg/l	1	17.00		17.00	17.00

NOTE: SU - standard units.

The onset of the Korean War created a need for more munitions and in 1952, the Atlas Powder Company, subsequently known as Atlas Chemical Industries, Inc., and ICI American, Inc., and now known as ICI United States, Inc., was contracted to operate the installation for the production of TNT. Five years later the plant was again placed on a standby basis with the Atlas Powder Company providing protective surveillance until the end of 1964, at which time FCAI took over this service. With the escalation of the Viet Nam conflict, it was necessary to increase the supply of TNT with the result that in October 1965 a contract was awarded to Atlas Chemical Industries, Inc., to resume production. Production continued at a high level until the end of 1972. Production during mobilization levels is shown in table 9.

Table 9. TNT Production at Volunteer Army Ammunition Plant During Mobilization Periods

National defense effort	Period of operation	Production of TNT in tons
World War II	July 1942 - August 1945	411,653
Korean Conflict	June 1953 - March 1957	141,842
Southeast Asia Support Operations	October 1965 - December 1972	750,000

Official recognition of the pollution problems of VAAP seems to have been instituted on 2 December 1965 when a meeting was called by the Army with invited representatives of Tennessee Valley Authority (TVA) and other Tennessee State, county, and local health agencies. Personnel of VAAP promised that they would maintain air and water pollution levels at a minimum in accordance with all known criteria. Official recognition apparently was caused by numerous community protests over the increased quantities of acid fumes generated from the sulfuric acid concentrator unit, nitric oxides emitted from the Ammonia Oxidation Plant, and the red color of plant effluent that was being discharged into Waconda Bay, a prime recreation area serving a large population.

Continued public pressure in the latter part of 1966 served as the stimulus to inaugurate a series of projects at VAAP designed to abate air and water pollution. Some progress was made in the next 3 to 4 years as evidenced by a lessening number of complaints from the community, although in 1970, one suit was filed in Federal Court alleging pollution damage to neighboring property.

Most of the progress in pollution control at VAAP was made from July 1972 to the present as a result of commissioning and operating new production facilities. Much of the VAAP Basic Unit History during this period describes problems that have occurred during the startup of new facilities.

In January 1975, the plant changed from a one-line batch process to a one-line automated continuous process production schedule. This has been in operation up to the present time.[15]

C. Topography and Drainage.

The administrative area, TNT lines, and FCAI facilities are located in a valley of gently rolling land, ranging from 678 to 750 feet above mean sea level; the valley runs north and south. The terrain rises sharply to a western ridge along the plant boundary where the water filtration facilities are located, while to the east the maximum elevations (1,000 feet) are in the magazine and buffer areas. The topography is described as undulating to hilly or semi-mountainous[16] over more than half of the installation.

Surface drainage of VAAP is shown in figure 5. The northwest corner of the facility drains north through ponds 4 and 5 into Waconda Bay. This includes surface runoff and wastewaters from FCAI, the TNT production area, and both acid areas.

The remaining drainage and wastewaters from FCAI and runoff from the administrative and shop areas flow south through Poe's Branch to Friar Branch.

Manufacturing activities are restricted to the western third of VAAP. Surface runoff and industrial wastewaters flow north through ponds 4 and 5 into Waconda Bay and south through two oxidation ponds into a tributary of Friar Branch. The east acid stream, new acid area stream, and the east TNT stream combine before entering pond 4. This is joined as it flows north by industrial and surface drainage from the west stream. The east acid stream receives surface drainage and leachate from the old east acid area (no longer in use), compressor blowdown from building 401-2, cooling water and surface drainage from building 401-2, and wastewaters from the new acid area acid sewer. The new acid area stream receives blowdown from the primary boilers in building 415, storm sewer drainage, effluents from a 5,000 gal/day package sewage treatment plant and a laundry, and overflow from the cooling tower blowdown sump at the Industrial Liquid Waste Treatment Facility (ILWTF). Wastewaters that bypass the ILWTF are routed to a new holding pond. The east TNT stream receives surface drainage from TNT lines 13 through 16 (on standby) and continuous TNT lines 1 through 6 (only line 1 is now in use), spills of acid, redwater and yellowwater from TNT line 1, a portion of batch lines 1 through 6, and drainage from two waste acid pits. The east stream into pond 4 also receives condensate and surface drainage from the redwater plant.

The west stream into pond 4 is formed by drainages from the west TNT stream, FCAI, and overflow from the silt retention pond. The west TNT stream receives surface drainage from part of old batch TNT lines 1 through 6 (standby status) and effluent from a 150,000-gal/day sewage treatment plant with secondary treatment. The FCAI waste stream contains filter backwash from the water treatment plant, surface drainage, and cooling water.

The Poe Branch of Friar Branch drains the central magazine area of VAAP to the south. These branches converge with the FCAI and discharge in Friar Branch, a tributary of South Chickamauga Creek. The eastern third of VAAP drains north through Harrison Branch and northeast through Wolftever Creek into Harrison Bay.

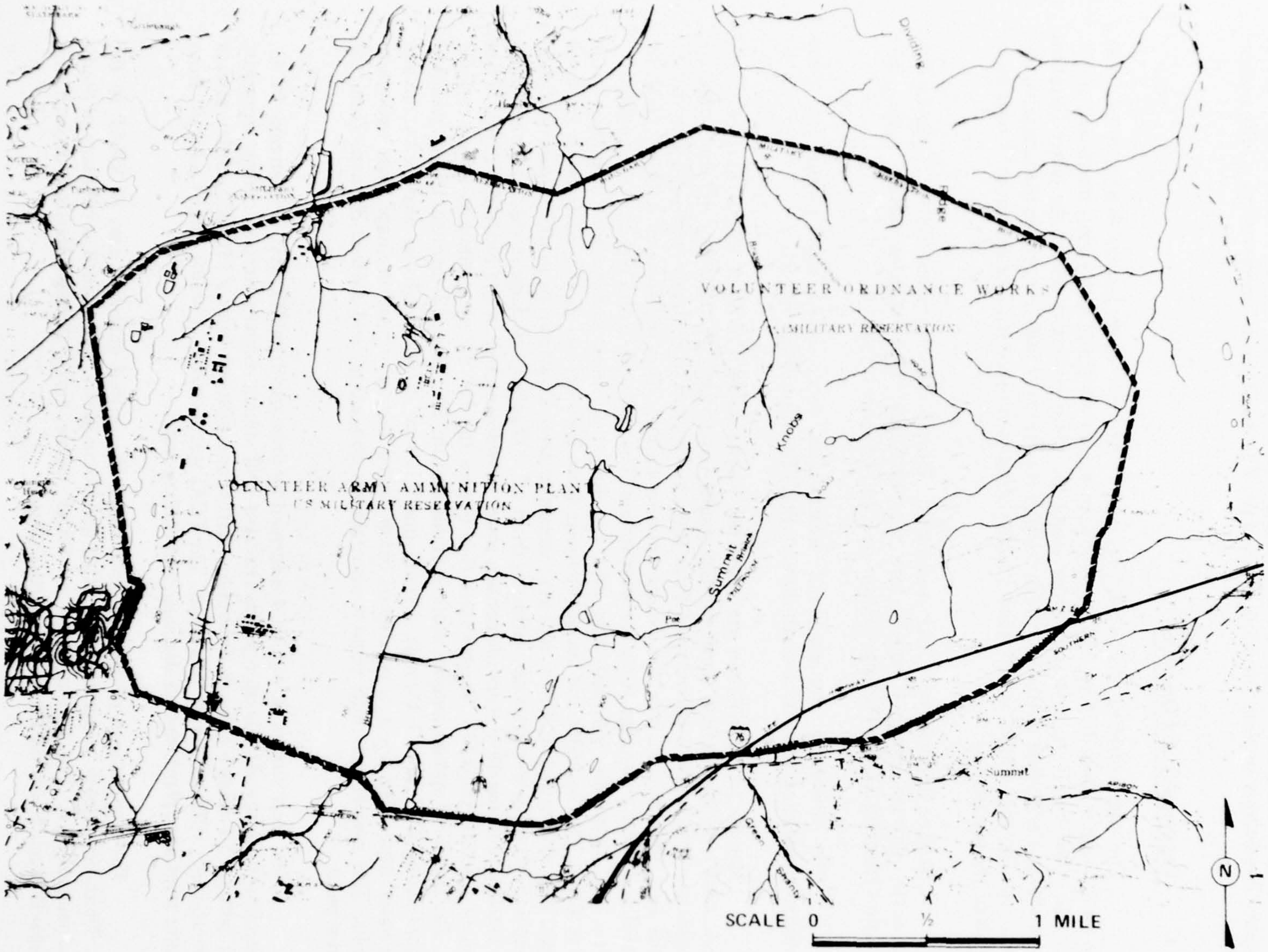


Figure 5. Surface Drainage and Topography of Volunteer Army Ammunition Plant

D. Installation Air Quality.

Monitoring of ambient levels of nitrogen oxides (NO and NO_2), sulfur dioxide (SO_2), sulfuric acid mist, and suspended particulates was initiated by ICI-US at four locations in 1966 and has continued until the present time.[17]

Three of the four locations are shown in figure 6. The original sites are identified as MS-1, F-1, F-2, and F-3. F-1 (Rod and Gun Club, Waconda Bay) is not shown. The designation MS– signifies mobile sites and F– signifies fixed sites. F-3 had been located in building T1035 until November 1974 when it was moved to its present location (figure 6).

From 1966 through 1974, NO, NO_2, and SO_2 data procured from each of the four ambient air monitoring stations were averaged for 1-hour time segments, and these figures were then used to compile 24-hour averages which in turn were used to compute monthly averages. The same breakdown of data was used to develop particulates and sulfuric acid mist monthly averages, although 24-hour composite data were used initially.[17] The methods used in monitoring ambient air quality can be found elsewhere.[18] Due to the volume of these data, the monthly averages of each of the four ambient air monitoring stations were totaled and averaged to develop an overall monthly ambient average of the years 1966 through 1975 (figure 7).[18]

The monthly ambient air averages of VAAP in figure 7 show a definite improvement in ambient air quality since 1969 when the pollution abatement units were put into effect. The Environmental Protection Agency ambient air quality standards have been attained in most cases. NO_2 ambient values were borderline at the 0.05-ppm level during 1974, but these fell below the ambient air quality standards[7] at every station in 1975 except during April and May where the NO_2 values were 0.071 and 0.061 ppm, respectively, at the pond 5 station (table 10). The NO_2 values have been less than the ambient air standards for the months of January and February 1976.

The average ambient air concentrations for SO_2 at VAAP are well below the 0.014-ppm 24-hour standard (figure 7). Monthly averages for each station for March 1975 to February 1976 (table 10) show that this is not true for each station. The SO_2 values were above the standard of 0.014 ppm[7] during April and December 1975 and January and February 1976 at the gate 20 station. The average daily ambient air quality reports from ICI-US[17] show that for a total of 56 days during those 4 months, levels were above the SO_2 ambient standards set by the Chattanooga-Hamilton County Air Pollution Control Board.

The average concentrations for suspended particulates at VAAP (figure 7) have shown a continuous decrease since 1966 and, from 1973 to the present, the overall averages for each month have been well below the State of Tennessee's ambient air quality level of 150 $\mu g/m^3$.[7] The monthly averages for each station (table 10) also show that the particulates have been maintained well under the ambient standards, and only 4 days have been recorded during the period of March 1975 to February 1976 with an average slightly above the 150 $\mu g/m^3$ level.

The local air quality standards are less stringent than Federal requirements, with a particulate level of 75 $\mu g/m^3$. During 1973 and 1974, the overall ambient air data show that there were 6 months in which the level of 75 $\mu g/m^3$ was exceeded.[19] The monthly averages for each station show that in April 1975 the pond 5 station exceeded the local level, and that during 122 days of 1975 the ambient concentrations exceeded the 75 $\mu g/m^3$ level set by the Chattanooga Hamilton County Air Pollution Control Board.[7]

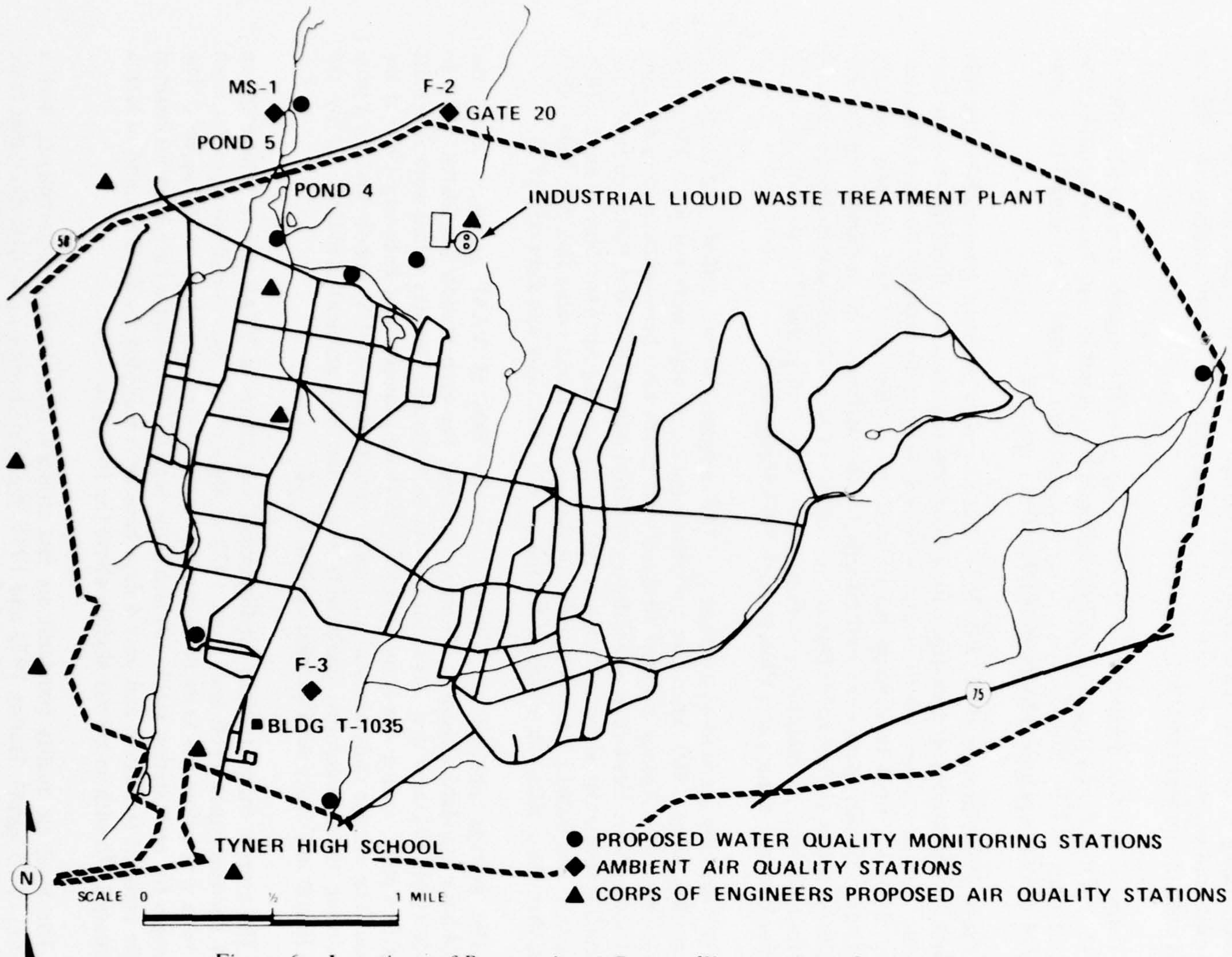


Figure 6. Locations of Proposed and Current Water and Air Quality Monitoring Stations on Volunteer Army Ammunition Plant

In addition to stations shown on the map, air quality is also monitored at the Rod and Gun Club on Waconda Bay, and water quality is monitored at seven locations in Waconda Bay.

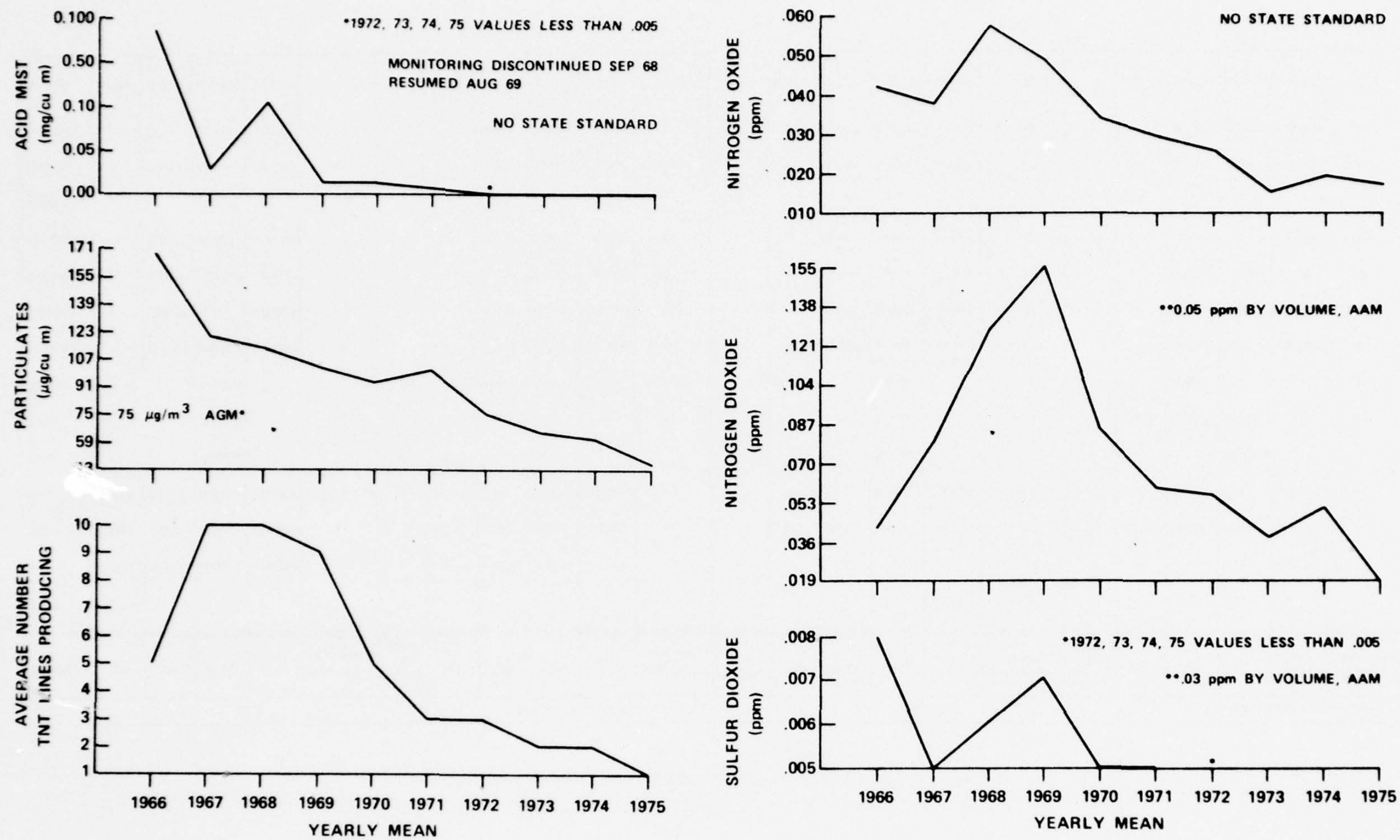


Figure 7. Ambient Air-Quality Monitoring Data from Volunteer Army Ammunition Plant

Table 10. Average Monthly Ambient Air Quality at Volunteer Army Ammunition Plant

(April 1975 - February 1976)

	Pond 5						Rod and Gun Club						Gate 20						Environmental Laboratory					
Month	NO	NO_2	SO_2	Acid mist	Suspended particulates	No. of TNT lines	NO	NO_2	SO_2	Acid mist	Suspended particulates	No. of TNT lines	NO	NO_2	SO_2	Acid mist	Suspended particulates	No. of TNT lines	NO	NO_2	SO_2	Acid mist	Suspended particulates	No. of TNT lines
1975																								
March	0.0283	0.0359	0.0111	<0.005	42	1	0.0213	0.0242	0.0051	<0.005	36	1	–	–	–		42	1	–	–	–	<0.005	29	1
April	0.049	0.071	0.014	<0.005	92	1	0.03	0.03	0.003	<0.005	61	1	0.027	0.011	0.026	<0.005	62	1	0.029	0.024	0.001	<0.005	50	1
May	0.055	0.061	0.010	<0.005	68	1	0.022	0.04	0.002	<0.005	65	1	0.012	0.027	0.005	<0.005	66	1	–	0.016	0.002	<0.005	61	1
June			No data			1			No data			1			No data			1			No data			1
July			No data			1	–	–	–	–	51	1			No data			1	0.006	0.007	0.001	–	51	1
August			No data			1	–	0.015	–	–	54	1			No data			1	–	0.003	–	–	49	1
September	–	–	0.00	<0.005	36	1	–	0.013	0.00	<0.005	47	1	–	0.003	0.00	<0.005	33	1	–	0.009	0.00	<0.005	41	1
October	–	0.015	0.00	<0.005	45	1	–	0.031	0.00	<0.005	50	1	–	0.010	0.001	<0.005	40	1	–	0.016	0.00	<0.005	33	1
November	–	0.029	<0.005	<0.005	37.9	1	–	0.020	0.005	<0.005	41	1	–	0.006	0.004	<0.005	36.3	1	–	0.009	<0.005	<0.005	36.8	1
December	–	0.022	0.003	<0.005	37	1	–	0.021	0.007	<0.005	45	1	–	0.012	0.016	<0.005	36	1	–	0.009	–	<0.005	32	1
1976																								
January	–	0.019	0.005	<0.005	45	1	–	0.022	0.007	<0.005	39	1	–	0.015	0.033	<0.005	35	1	–	0.011	0.013	<0.005	32	1
February	–	0.017	0.001	<0.005	59	1	–	0.025	0.005	<0.005	56	1	–	0.017	0.029	<0.005	66	1	–	0.045	0.008	<0.005	49.3	1
Average	0.0441	0.0337	0.0055	<0.005	51.7	1	0.0244	0.0241	0.0039	<0.005	49.55	1	0.0195	0.126	0.0135	<0.005	46.3	1	0.0175	0.0149	0.0038	<0.005	42.2	1

Since 1972, the acid mist data have continuously shown levels less than 0.005 $\mu g/m^3$. One other factor contributes to the high concentrations of pollutants in ambient air quality. Air stagnation due to the climate and topography of VAAP tends to restrict the dispersion of the discharges from the facilities. A more detailed discussion is given in the climate and topography sections of this report (section II.B. and C. and section III.C.).

Figure 7 shows the trend for the overall yearly averages for each pollutant monitored for the period of 1966 through 1975.

The pollution abatement systems alone were not the only reason for the continuous increase in ambient air quality since 1968. There also has been a massive cutback in production and the number of TNT lines used since that time (figure 7). In 1968, the plant was operating with a full 10 TNT lines. Each year since, there has been a continuous decrease in the number of lines used; presently, only one line is in operation.

These graphs show that there has been a definite decrease since 1969 in each parameter monitored. This is not to say that the problems have been completely solved, since NO_2 and SO_2 still reach levels above the ambient air quality standards, but a continuous improvement has been seen since 1969 and this must be continued if the problem is to be completely solved.

There are plans for continuing the monitoring of ambient air quality at these four stations and also for expanding the program with the installation of eight new mobile trailer monitoring units. Personnel of the US Army Corps of Engineers are presently in the process of installing these units around the installation. The comprehensive plan is also shown in figure 6. These trailers will be equipped to monitor a greater variety of air quality parameters to give a more comprehensive view of ambient air quality. These units will also be equipped with an alarm system which will be tied into a centrally located panel at VAAP.

E. Installation Water Quality.

The liquid wastes generated by VAAP flow north through pond 4 (after which there is a pH adjustment) and then into pond 5 for sedimentation before being discharged to Waconda Bay. pH is monitored continuously below pond 5 where it can be further adjusted if needed.

Since the inception of the EPA permit program in May 1974, followed by more stringent standards as of 1 July 1977 (table 11), VAAP has been issuing monthly reports in terms of milligrams per liter (ppm) and pounds per pollutant produced per day based on the average monthly flow rates. At the present time, it would not be advantageous to average all of these reports to determine overall average flow or pounds pollutant per day because flow rates have been progressively reduced as the result of production cutbacks, equipment modernization, and other factors. During 1974, effluent flows were as high as 10 Mgal/d, but later rates gradually diminished to 5 Mgal/d, the present level. The NPDES permit[20] does not provide limitations on TNT or any specific condensate wastewater components. These are measured by a colored complex as total nitrobody. Recent data from US Army Medical Research and Development Command, Ft. Detrick, indicate that this wastewater includes 32 different compounds.

The wastewaters that flow in a southerly direction on VAAP flow through a series of holding ponds into a tributary of Friar Branch and ultimately into Nickajack Lake. The feeder streams that produce this southern discharge originate primarily on the land leased by FCAI. Other

Table 11. Discharge Limitations for Volunteer Army Ammunition Plant Under Its NPDES Permit, 1 July 1977-30 April 1979

Parameter	Daily average		Daily maximum	
	mg/l	lb/day	mg/l	lb/day
Ammonia (as N)	0.1		0.5	
BOD_5	–	66	10	
COD	–	–	20	
Total chromium	–	0.33	0.05	
Copper	–	0.13	0.02	
Dissolved solids	750		1,000	16,700
Iron	–	–	0.3	5.0
Lead	–	0.33	0.05	0.83
Manganese	–	–	0.05	0.83
Mercury	0.002	0.013	0.005	
Nitrate and nitrite	–	–	10	170
Oil and grease	10	–	15	250
Phenol	–	0.007	0.01	0.017
Phosphate	–	–	0.1	1.7
Settleable solids	–	–	0.5	
Sulfate	–	–	250	4,200
Suspended solids	30	–	60	1,000
TNT and nitrobodies	0.3	–	0.5	8.3
Temperature (°C)	–	–	32.2°C	

NOTES: The pH shall not be less than 6.5 standard units nor greater than 8.5 standard units and shall be monitored continuously.

There shall be no discharge of floating solids or visible foam in other than trace amounts.

minor sources of flow to this stream include infiltration from inactive sections of the VAAP sewage collection system and surface drainage from the administration and shop areas. Since theoretically no industrial waste is discharged from VAAP to Friar Branch, this stream will not be discussed in this section. Water quality in Friar Branch is discussed in section II.E.

1. Monitoring Program.

Monitoring of the effluent from pond 5 and at several other locations in Waconda Bay was started in 1966 by VAAP before there were any EPA requirements for the effluent. Daily, 24-hour composite samples were procured for most parameters measured in pond 5 effluent. Sampling for pH was on a continuous basis. Grab samples in Waconda Bay were taken weekly.

During the same period of time, weekly grab samples of raw water (intake water) were also taken to maintain a record of the raw water quality. This was important because the raw water intake is only a few miles downstream from pond 5 effluent.

In September 1974, WAPORA, Inc., initiated a water monitoring program at VAAP.[21] Three sampling stations were set up in Waconda Bay (two of which will be discussed later in this section). All of the grab sample parameters, except for dissolved oxygen (DO), pH, conductivity, and water temperature, were analyzed in a laboratory. These were continuously recorded in the field.

Water and Air Research, Inc., (WAR) initiated an aquatic survey in Waconda Bay during the periods of 9–13 June and 11–15 August 1975.[22] Six water quality monitoring stations were set up in Waconda Bay. Three of these sites will be discussed and compared to other results later. The analysis was performed on grab samples and DO, temperature, pH, and conductivity were continuously recorded in the field. Unfortunately, ICI-US was on strike and TNT was not being produced during the survey period.

ICI-US at VAAP is currently expanding the water quality monitoring program. Sites are being prepared by the Corps of Engineers under MCA Project Number T01000, FY73.

The data[23] presented in this report are from selected sites in each of the three monitoring programs, since the total amount of data from all the stations are far too voluminous to include. The stations selected for this report give a representative summary of the quality of the discharge water from VAAP and its effect on Waconda Bay as it flows into the Tennessee River. The location of each is shown in figure 8, with data having been collected at stations 1 through 3 by ICI-US, Inc., Water and Air Research, Inc., and WAPORA, Inc. Station 4 (upstream Tennessee River) was sampled by WAR, Inc., and A (pond 5 discharge), and B (raw water intake) were sampled by ICI-US, Inc.

2. Trends in Water Quality.

Trends in water quality since the inception of the monitoring program by VAAP in 1966 are shown by yearly averages computed for each parameter monitored. Figure 9 summarizes the yearly averages for five of the monitoring stations.[17] These data are not to be interpreted as the exact concentration of pollutants at each station, but are to be used only to compare the stations with each other because they are yearly means.

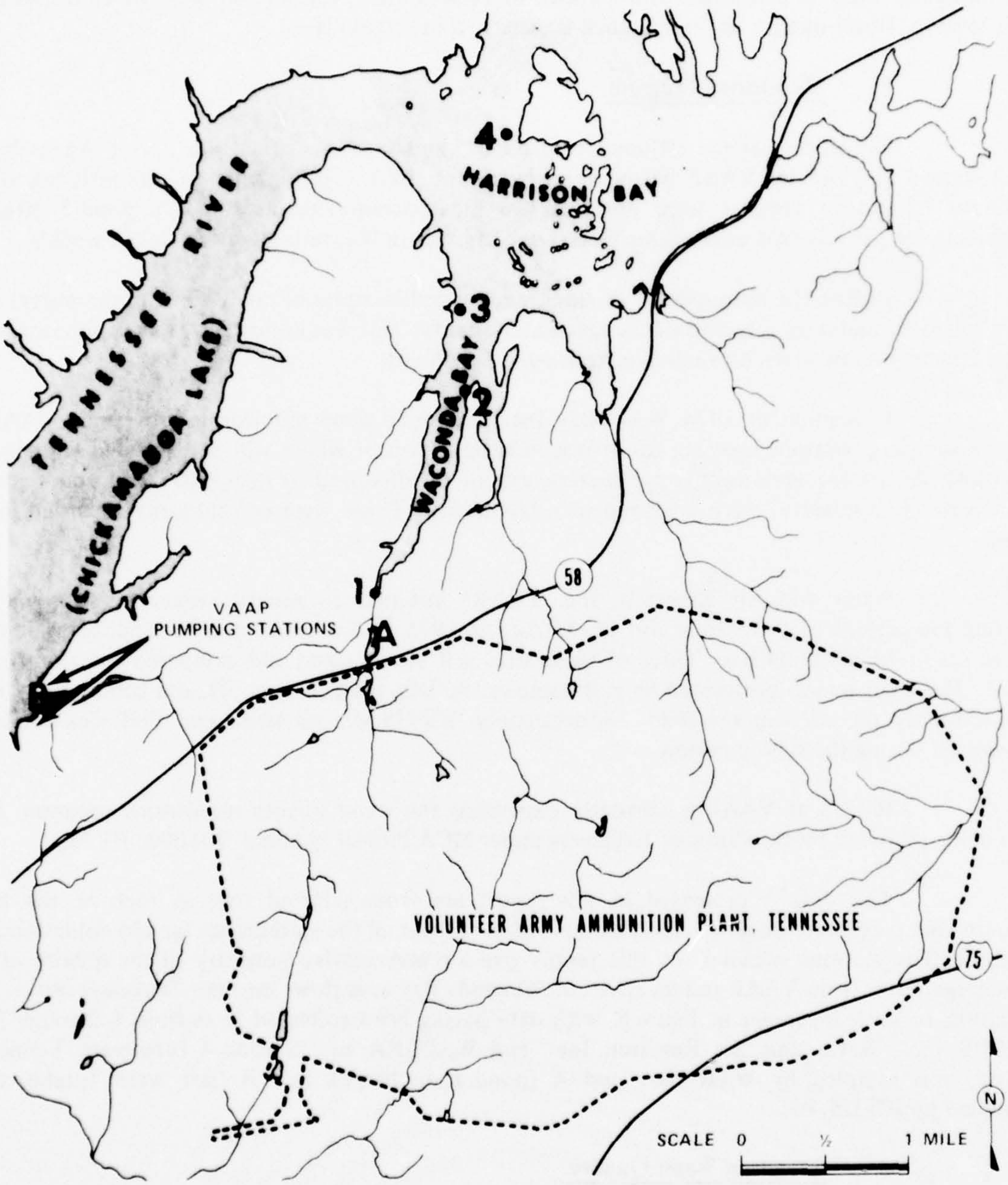
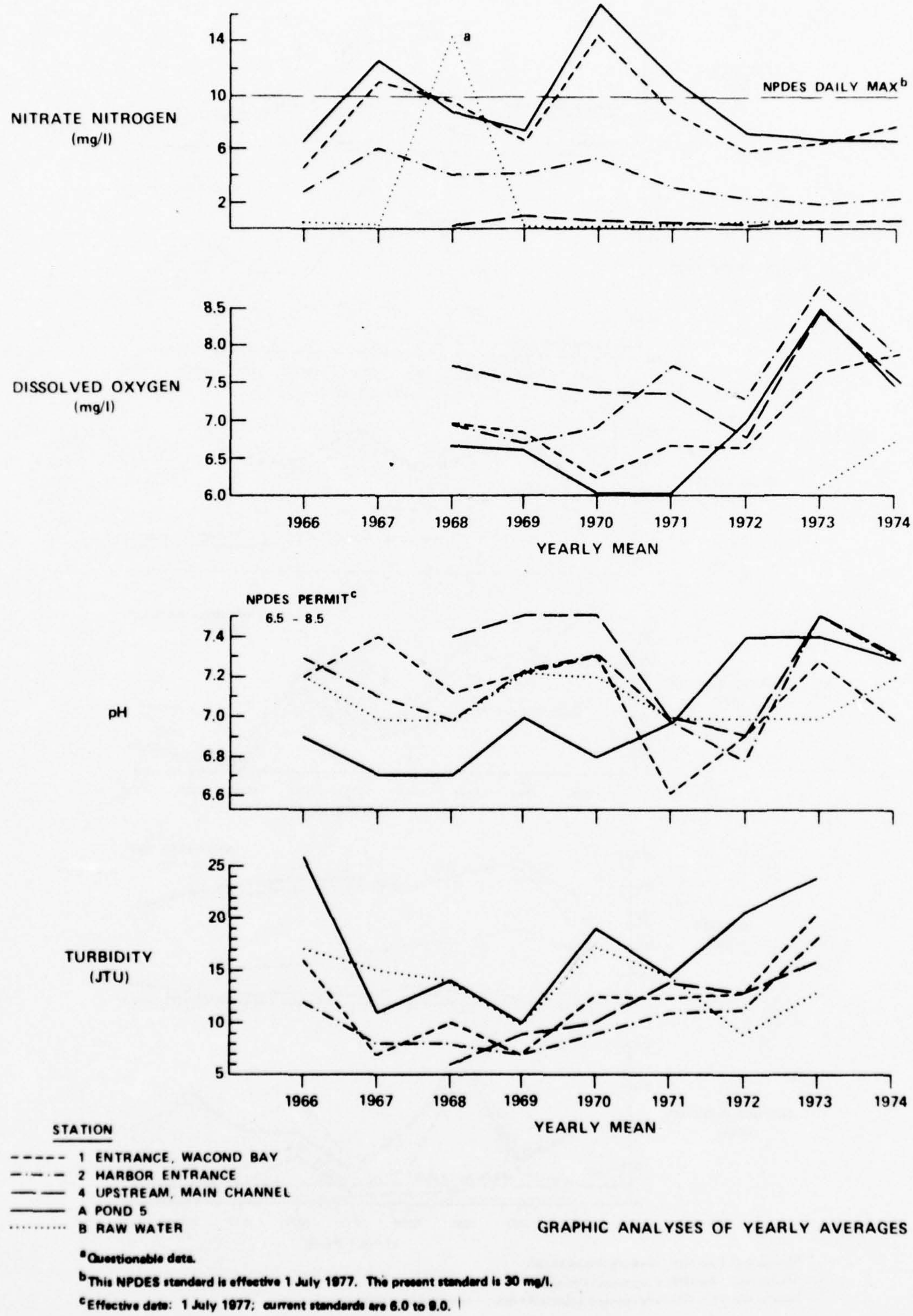


Figure 8. Locations of Water Quality Monitoring Stations Utilized by VAAP, Water and Air Research, Inc., and WAPORA, Inc.

Stations A and B were monitored by VAAP only.

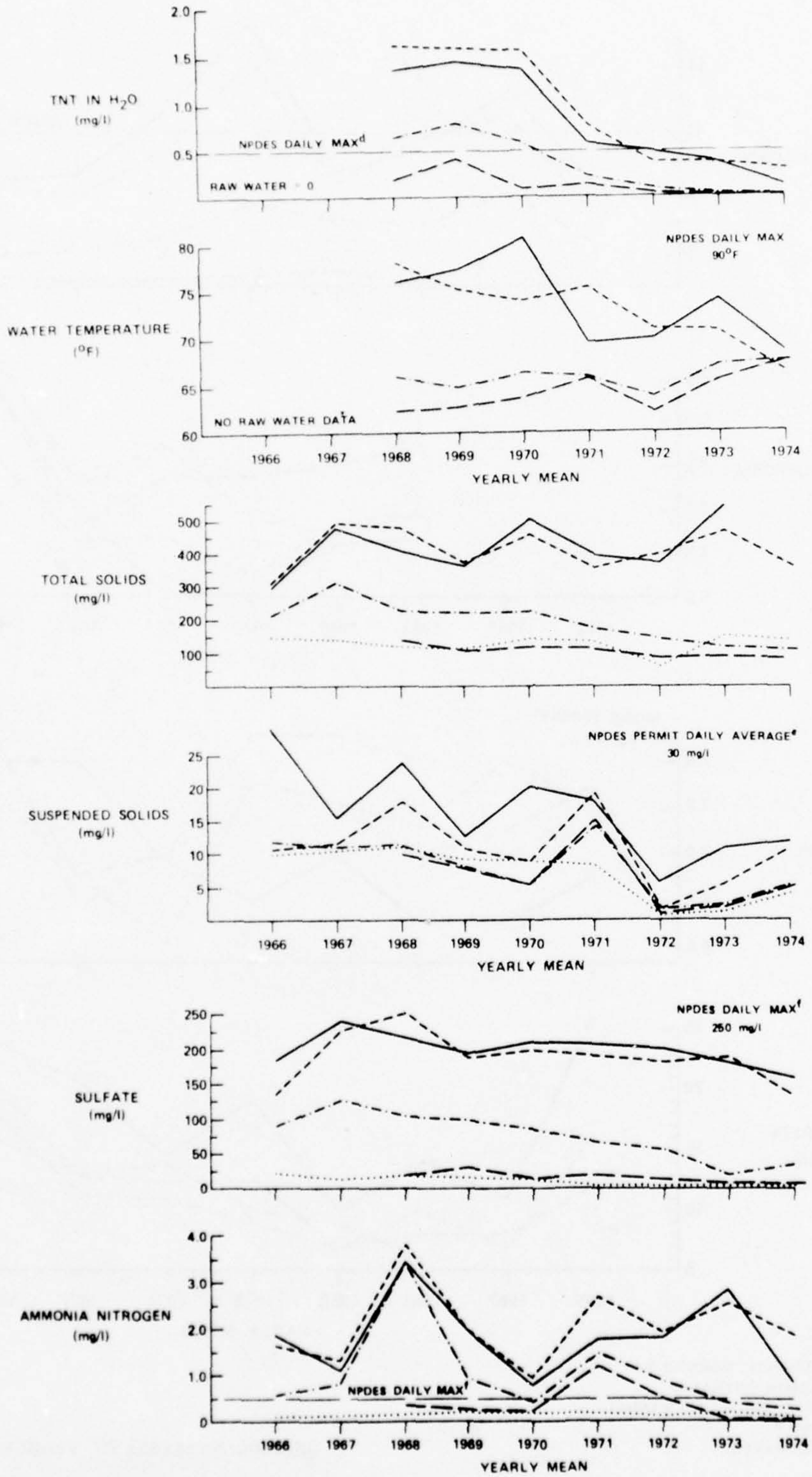


[a] Questionable data.

[b] This NPDES standard is effective 1 July 1977. The present standard is 30 mg/l.

[c] Effective date: 1 July 1977; current standards are 6.0 to 9.0.

Figure 9. Yearly Averages of Water Quality Measured by VAAP in Waconda Bay and Its Main Discharge



[d] Effective date: 1 July 1977; current standards are 3.0 mg/l.

[e] Effective date: 1 July 1977; current standard is 60 mg/l.

[f] Effective date: [illegible] 1977; current standards, sulfate (2,000 mg/l) [illegible] ammonia nitrogen (2.0 mg/l).

Figure 9 (Contd)

The yearly summary clearly shows that there is little difference between the quality of this water in pond 5 and the quality of the discharge water as it enters Waconda Bay. The graphical analysis also shows the high dilution factor of the water in Waconda Bay as it flows toward the Tennessee River. The harbor entrance and the main channel of the Tennessee River are affected very little by the discharge from VAAP. The intake of raw water to the plant is located 2 miles downstream from the discharge point at pond 5. Monitoring of the quality of the intake water has continued since 1965, and the quality has remained relatively constant.[19] Figure 9 clearly shows that the quality of the water in the main channel and that of the raw water intake varies little, and that the quality of water at the harbor entrance is slightly affected by the discharge water.

There has been a significant improvement in the quality of Waconda Bay samples since the 1966 to 1970 era. During this period, it was not unusual to see the entire bay exhibiting a pink to red color. This was attributed to the high TNT content of the pond 5 effluent. During this period, several fish kills had been experienced as the result of inadequate pH control.

At the present time in Waconda Bay, water color is normal, and fish have moved back into the bay.[17] However, pond 5 is still discharging a high level of pollutants, as will be discussed later in this section.

Unpublished data from surveys conducted in December 1975 and February 1976 show that the effluent from VAAP can be distinguished along the west bank of Waconda Bay. This water mass was tracked by its high conductivity in December. In February, VAAP was preparing to close and the discharge was unusually concentrated. Munitions compounds were generally present throughout the bay. From the preliminary results of biomass in periphyton, there was a significant biostimulation of the periphyton growth on microscope slides down bay of the cable crossing. Additional information will be available in the final report of that survey.

3. Discussion of Monitoring Data.

The wastewaters sampled at station A are characterized as a warm, poorly buffered, highly conductive effluent, predominantly sulfate and calcium ions, containing high concentrations of dissolved solids. Comparison of the permitted discharges with the plant records[19] for the period October 1974 (when the permit came into effect) to December 1974 showed that a number of parameters exceeded the set limits. During 1972, an EPA study summarized in STORET also examined the characteristics of VAAP wastes discharged from pond 5. The parameters exceeding NPDES specifications during the two periods are listed below.

NPDES monitoring (1974)	EPA study (1972)
Ammonia	BOD
BOD	Ammonia
COD	Suspended solids
Nitrate	Phosphate
Nitrite	Iron
Chromium	Chromium
Copper	Copper
Manganese	Lead
	Manganese

During 1975 and at the beginning of 1976, NPDES monitoring data showed an increase in the number of parameters in noncompliance with the NPDES specifications. Table 12 shows the parameter in noncompliance during the period of March 1975 to February 1976 and also the number of times per month the specifications were exceeded.[17] The decline in pollutants shown during the period of June 1975 to September 1975 was due to a labor dispute at which time the plant was not operating. The NPDES monthly average data of pond 5 for 1974, 1975, and for January and February 1976 are shown in appendix A. The data from pond 5 during January and February 1976 (in appendix A) show those concentrations which were in noncompliance with NPDES permit standards for VAAP discharges. The data from station 1 (figure 9), as the discharge enters Waconda Bay, directly correlates with that from pond 5 except that data in the WAPORA report show levels considerably less than the NPDES data and those in the WAR report. A summary of these reports is shown in appendix B. The data show that the discharge from VAAP has a significant effect on the water quality at the harbor entrance station. The discharge, however, has very little effect at station 3 where it enters Harrison Bay and no effect on the main channel of the Tennessee River. Two problems with these data should be highlighted here. First, VAAP was not actively producing TNT during the survey by WAR, Inc., and second, no samples were taken of the bottom macroinvertebrate community which would be more likely to represent impacts from previous production periods.

TNT was found at stations in Waconda Bay by WAR, Inc., as had been found by WAPORA, Inc., during a period of active production; therefore, we conclude that current studies are insufficient and the extent of TNT invasion and effects in Waconda Bay should be investigated with comparison of periphyton and macroinvertebrate surveys during a period of active production.

Modernization projects are currently underway to alleviate these problems and achieve compliance (discussed in a later section). These modifications were planned to be in effect in 1976. When all modernization facilities are operating at peak efficiency, the amount of water discharged from pond 5 will be less than 5 Mgal/d.[17]

F. Natural Resources.

1. Flora.

The Department of Biology of the University of Tennessee at Chattanooga has performed a partial study of the flora of VAAP. This document would reflect much of the flora of VAAP.*

Two studies conducted by TVA reflect, to a limited degree, the composition of the flora of the areas surrounding VAAP. An environmental impact statement prepared by TVA for the Sequoyah nuclear plants 1 and 2 is the most complete list available for future work at VAAP.[24] The Brainerd Flood Relief Plan contains a limited number of plant species for the area.[25] Sixty-nine species of trees, shrubs, and vines are identified as indigenous to the area.

In a compilation of studies of the flora of various gorges of the southern Cumberland Plateau and eastern highland rim, Dr. Caplenor, Georgia Teachers College, Collegeboro, Georgia, studied the flora of the Fall Creek Falls State Park, Tennessee.[26] The park is approximately 45 miles from VAAP, and the similarity between the flora identified for the park and the flora identified by TVA makes the probability quite high that VAAP has a similar flora. Trees listed in the Forest Management Plan for VAAP[27] are similar to those found in the work for the Brainerd Flood Relief and Caplenor's study, although VAAP has listed fewer species.

*Dr. Perfetti, Professor of Biology, University of Tennessee, Chattanooga, personal communication.

Table 12. Frequency of Noncompliance Each Month with NPDES Permit at Volunteer Army Ammunition Plant

Parameter units	1975										1976	
	MAR	APR	MAY	JUN*	JUL*	AUG*	SEP*	OCT	NOV	DEC	JAN	FEB
mg/l												
Ammonia (as N)	1	4	7	1	3	3	5	8	5	9	7	8
Biochemical oxygen demand (BOD)	1	4	3					2	2	1		2
Chemical oxygen demand (COD)	2	8	6	4	1	1		6	3	4	3	4
Chromium			1	1			3					
Copper			2	3	1				2	2	2	4
Dissolved solids	4	8	6					4	1	5	4	2
Iron			1		1	1	1	1	1	1	1	1
Manganese	3	4	5	4	4	5	4	5	4	5	4	4
Nitrate and nitrite (as N)	1	8	7	1		1		6	3	5	8	8
Oil and grease	1		4					1	3		2	2
pH**	12.05 hr	18.6 hr	44.77 hr	80.63 hr	26.2 hr	10.25 hr	0.95 hr	85 min	63 min	194 min	140 min	196 min
Phosphorus (as P)	2										1	1
Sulfate		7	5			1		6	4	5	7	3
Suspended solids	1	3	1	5	2	2	2			1	2	1
Temperature**				5.75 min	18.5 hr	20.25 hr	3.9 hr					

*Plant closed by labor dispute.

**pH and temperature are recorded continuously below pond 5.

While there are no definitive studies of the flora of VAAP, there are, however, a number of taxonomic keys to various types of plantlife of eastern Tennessee that should be consulted in any future studies. Shanks and Sharp, University of Tennessee, Knoxville, Tennessee, identified the trees of eastern Tennessee.[28] Shaver and Sharp, University of North Carolina, and University of Tennessee, respectively, listed the ferns and bryophytes of Tennessee.[29-31] Skorepa compiled a catalog of the lichens of Tennessee.[32] Phillips published a list of foliose and fruticose lichens of Tennessee,[33] and Dey identified two new lichens from the southern Appalachian Mountains.[34]

The Chattanooga, Tennessee – Rossville, Georgia Interstate Air Quality Study conducted preliminary studies on the effects of air pollutants on plants in the vicinity of VAAP in 1967 and 1968.[35] The studies consisted of visual and analytical methods of detecting damage to vegetation resulting from airborne pollutants. The studies disclosed the necessity for additional studies of the effects of nitrogen dioxide, ozone, PAM, sulfur dioxide, and hydrogen fluoride on selected vegetation, especially plants of commercial value in the area, including tobacco, pinto bean, petunia, begonia, geranium, and tomato,[35] and timber crops.

Three species of plants indigenous to the area and possibly present on VAAP are considered rare, endangered, or threatened: Skunk cabbage, *Symplocarpus foetidus*, Ginseng, *Panax quinquefolius* and white lady's slipper, *Cypripedium acaule*.[36,37] Further studies are needed to confirm their status at VAAP so that future activities at VAAP will not jeopardize their habitats.

2. Fauna.

The nature of VAAP's mission has permitted very little ecological work. However, the installation has cooperated with the State in several stocking programs, as described in the Installation Fish and Wildlife Management Plan. The blacktail deer (mule deer) population existing at VAAP is the result of one such stocking program. These deer were brought to the installation from Oregon in 1966 and 1967. The herd has grown to the extent that bow-hunting is necessary for proper management. The only whitetail deer found on the installation are those that escaped trapping prior to the blacktail deer stocking project. Crossbreeding apparently occurs between species. Hunting small game animals was a source of recreation before these privileges were rescinded in 1971 at the order of the VAAP Commander. There is no evidence that limited public access has significantly changed the quality of the installation's biota.

There are no extensive lists of animal species on the installation. The only lists available are included in the Fish and Wildlife Management Plan, and these are incomplete and contain only common names. Information on the surrounding faunal resources can be found elsewhere.[38-46] A list of 27 species of mammals found in the Cumberland Mountains up to 2,000-feet elevation is available.[38] Another source is the observations of mammals in Johnson and Carter counties, Tennessee,[39] which includes species from 3,000 to 4,000 feet in elevation. Also available are the handbook and field guide for mammals of North America[40] and Eastern United States.[41] The 1972 preliminary list of birds of Tennessee by Alsop[42] is an update of Ganier's previously published preliminary list,[43] but it does not include distributions or relative abundances. In the immediate vicinity of the installation, members of an ornithological society have been active in field identification.* The most relevant list of reptiles (contains 26 species)[44] is included in the study from southern Tennessee and northern Georgia. A list including 38 species of reptiles and

*Dubke, K., and Dubke, L. May 1976. Roy Lane, Ooltewah, Tennessee 37315. Personal communication.

amphibians was compiled in association with a study of water quality in the Obey River and its tributaries of the Eastern Highland and the Cumberland Plateau in Tennessee.[45] A list of aquatic invertebrates was compiled by the TVA for an environmental study in the South Chickamauga Creek about 5 miles southwest of the installation.[46] Macroinvertebrates were also collected in Waconda Bay into which VAAP drains its wastes.[46] In this study, 22 collections were made from natural and artificial substrates during June to September 1975. Of the 54 taxa enumerated, dipteran larvae (especially chironomidae) and tibificid worms (sludge worms) were the dominant groups. Both of these groups are similar in their responses to environmental conditions and seem to be indifferent to variations in pH, oxygen concentrations, and turbidity. They will tolerate some organic enrichment but they prefer moderate to high nutrient concentrations. This study indicated that TNT production wastes reduced community diversity as intolerant species were eliminated and replaced by a few of the more tolerant species. Water and Air Research, Inc., noted that community recovery and increased species diversity occurred more rapidly on artificial rather than natural substrates. A comprehensive bibliography of the zoological studies in Tennessee and the Tennessee River Valley region, with a one-sentence description of each study, is available.[47]

3. Habitats.

The climax vegetation which normally occurs in this area is the Oak-Hickory-Pine forest. This typical forest is characterized by hickory, shortleaf pine, loblolly pine, white oak, and post oak, which are medium tall to tall broadleaf deciduous and needleleaf evergreen trees. However, at VAAP, stands of pine trees have been planted and the entire forested area of the installation is managed for maximum timber production. Figure 10 indicates the forested areas. The tree species which may be found on the installation are included in appendix C. The only fields occur where areas are managed for fire prevention. This management halts succession in an herbaceous or a grassy stage and prevents invasion by woody vegetation.

Aquatic habitats include numerous small intermittent streams which dry up in summer months or are sustained by cooling or industrial wastewater. Also included are artificial spring-fed ponds, some of which are stocked with bluegill, largemouth bass, and catfish. The last of the aquatic habitats are the oxidation and settling ponds used for waste treatment and the reservoirs used for water storage.

The installation is not considered to have any unique habitats and, due to the timber harvesting, there are no areas in advanced stages of succession.

4. Geological Resources.

The entire Tennessee River Valley is underlain by Chattanooga Limestone formation of the Ordovician period. The Knox group, dolomite and limestones, are abundant on VAAP. These rocks are 2,500- to 3,000-feet thick and contain numerous sink holes and caverns. Sinks that are probably associated with this group have occurred in the east acid area and under one soda ash storage tank in the new acid area. Unfortunately, the Ooltewah and East Chattanooga quadrangles which detail the facility have not been completed by the Tennessee State Geological Survey; therefore, information on fault regions is not available.

The ridge and valley region was formed from limestone, shale, and sandstone ranging in geologic age from Cambrian to Carboniferous. Because most of the upper rock formations of the Cumberland Plateau are more soluble than those underlying, they weather more rapidly. As a result, the valley is lower than adjoining areas. The different solution rates of these rocks have caused intense folding and faulting.[48]

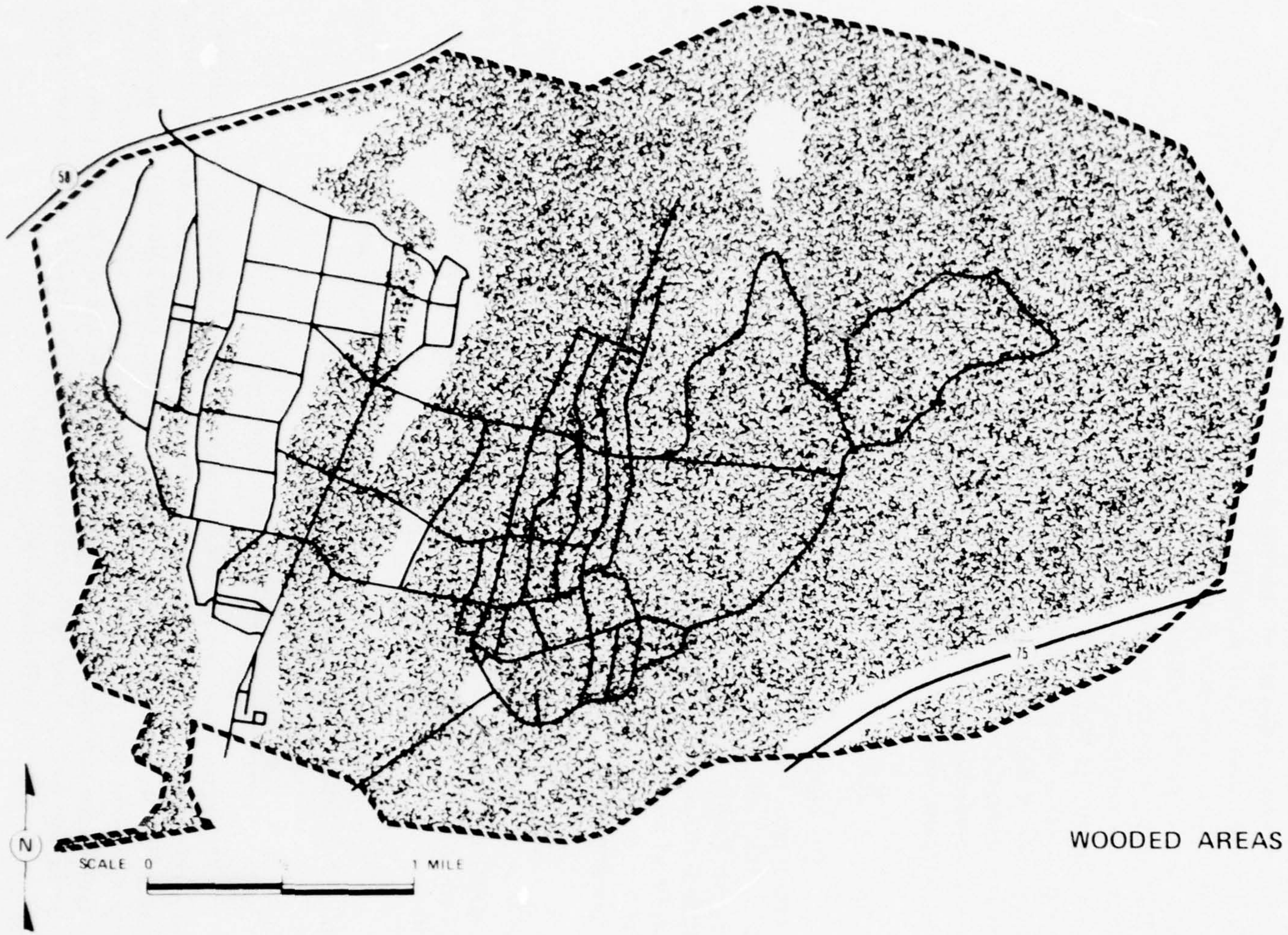


Figure 10. Woodland Areas of Volunteer Army Ammunition Plant

Much of Hamilton County contains black Chattanooga shale which is also found in portions of Alabama, Virginia, Kentucky, Indiana, and Ohio. In 1944, this shale was found to be a potential vast source of low-grade uranium ore. Extraction is currently impractical because the shale contains less than 0.006% uranium.[49] Coal has been mined extensively in Hamilton County although not on VAAP. From three deposits in the county, the Lantana, Sewanee, and Richland,[50] a total of nine beds have been worked intermittently.

Hershey, *et al.*[50] estimated that 53 million short tons of coal occurred in the known and measured beds of Hamilton County as of 1 January 1954.

Although no mining has been reported from VAAP, it is possible that coal, lead, and bauxite may occur there; however, detailed surveys for minerals have not been conducted at VAAP.

5. Soils.

The information presented here was obtained from an analysis of data provided by the district conservationist, Mr. Joseph Spencer, and the State soil scientist, Mr. Joe Elder. Data from the soil survey interpretations of each soil type were used to identify the engineering capabilities and the hydrological and erosion characteristics of each soil series found on VAAP. Soil series with similar descriptions and construction limitations were grouped together as critical areas. The distribution and the type of limitation were mapped but they are not included here. Aerial photographs delineating the soil distributions on the facility are available from the district soil conservationist in Chattanooga, Tennessee. The interpretations here are general and cannot be substituted for on-site soil surveys prior to construction or maintenance activities. However, the soil maps and the following descriptions should be useful, in combination with other maps included in this report, to locate potential areas for development, management, and maintenance in the existing plant area.

Major portions of the site soils have been modified for construction in the manufacturing and storage areas. Therefore, these areas are a mixture of surface and subsoils with construction fills that were not classified by the Soil Conservation Service (SCS). There were also three pits and two sink holes shown on both the SCS aerial photograph and the US Geodetic Survey topographic maps. The two largest such areas occurred near the old east acid area and the new acid area. A third category, not classified by SCS, was gullied land.

The first group of soils, Emory, Greendale, and Whitwell, consists of deep, well-drained soils formed in loamy alluvium on low-stream terraces, in depressions, and along narrow drainways. These soil series are sometimes flooded, generally between December and March. During this period, all have apparent water tables from 2.0- to 6.0-feet deep and, as such, these are a likely source of groundwater contamination. Although these soils are limited in occurrence at VAAP, they are common along Poe Branch near the administration area. They tend to be wet and unsuited for development and construction; however, they have a high fertility and are suitable for grassland and hay crops.

The Huntington and Lindside soil series consist of deep, well-drained soils formed in alluvium on nearly level plains, in upland depressions, and in sinks. These soils, associated with drainages on VAAP, were described from the Arrington series. They have moderate permeability and runoff, but construction activities are limited by annual flooding and seepage.

The Landisburg, Lobelville, Melvin, and Taft series (described from Stemley, Lobelville, Newark, and Gutherie, respectively) are poorly drained soils with clay fragipans which retain moisture. These soils with brown cherty silt loam are found in the lowlands and depressions of the central plant. Between December and April these soils have a perched water table from 0.5 to 5.0 feet below the surface.

The Clarksville series (described from Bodine) consists of deep, somewhat excessively drained cherty soils on sharply dissected uplands. This droughty soil predominates on the eastern portion of the property. The major problem here is the loss of vegetation on slopes due to droughts because erosion is a severe problem when this soil type is exposed. The combination of slope and seepage generally makes this soil unsuitable for construction. The excessive silt content (fines) also makes it a poor source for construction material.

The Bolton, Cumberland, Etowah, Hermutage, and Minvale series consist of deep, well-drained soils on foot slopes, stream terraces, alluvial fans, and high terraces. They have high productivity but are limited by seepage, and erosion is a problem when they occur on slopes of 7% or greater. These soils cover the majority of the central VAAP area. Waynesboro series, which is similar to this group, was also listed for the plant but it was not mapped. This soil is similar to those described above.

The Talbott series consists of shallow to deep, well-drained soils formed in clayey residum from limestone on the uplands. The soils percolate very slowly, and hard bedrock is 20 to 40 inches below the surface. The clayey overburden makes this soil undesirable for any landfill facilities, although it underlies portions of the burning and burying ground. Rock outcrops and shallow bedrock may be common and, in such cases, erosion would be difficult to control. Slopes bearing this soil are best utilized for woodland.

The Fullerton and Dewey series consist of deep, well-drained soils on uplands that are underlain by limestone. These soils are abundant in the production and storage areas and are commonly associated with limestone sinkholes. The clayey surface soil and severe slope require that considerable earthwork be performed prior to construction. The SCS recommends that this land be used for pasture and woodland. Because these soil series are associated with sinkholes, these sites should not be considered in future construction plans.

The Captina and Colbert series consist of deep, moderately well-drained upland soils. These soils have shallow bedrock like the Talbott series and occur on steep slopes in a belt through the central VAAP area. The cherty silty clay loam or cherty silt loam makes them highly susceptible to erosion. Many severe erosion problems caused by construction have occurred in this soil. Natural plantings should be encouraged along with Korean lespedeza as cover crops after timber harvest.

The principal soils on VAAP are shown in table 13. The woodland suitability groups for the soil series have been derived from a USDA progress report,[48] and brief descriptions of each group are included in appendix D. The progress report provides additional explanatory data which discuss the tree species and management practices which should be utilized for each woodland group.

6. Archaeological and Historical Resources.

The prehistoric Indians that occupied Tennessee can be divided roughly into three groups: Paleo, Archaic, and Woodland.

Table 13. Principal Soil Series from Volunteer Army Ammunition Plant

Soil series name	Description	Woodland suitability groups
Emory	Silt loam, 0%–5% slopes	2o7
Greendale	Silt loam and cherty silt loam, 0%–12%	2o7
Whitwell	Loam - silt loam, 0%–5%	2w8
Huntington	Silt loam, 0%–5% slope	2o7
Lindside	Silt loam and cherty silt loam, 0%–5% slopes	2w8
Landisburg	Silt loam and cherty silt loam, 0%–20% slopes	3o7
Lobelville	Silt loam and cherty silt loam, 0%–5% slope	2w8
Melvin	Silt loam, 0%–2% slopes	2w9
Taft	Silt loam, 2%–5% slopes	3w8
Clarksville	Cherty silt loam, 2%–15% slopes	3c8
Bolton	Loam - silt loam, 5%–20% slopes	3o7
Cumberland	Silty clay or clay, 5%–20% slopes, severely eroded	4c3e
Etowah	Silty loam to cherty silty clay loam, 2%–12% slopes	2o7
Hermutage		
Minvale	Silty loam and cherty silt loam, 2%–20%	3o7
Talbott	Silty clay, 5%–20% slopes, severely eroded	4c3e
Fullerton	Silt loam and cherty silt loam, 5%–20% slopes	3o7
Dewey	Silt loam, 2%–20% slopes	3r8 3o7
Captina	Silt loam, 0%–12% slopes	3o7
Colbert	Silt loam to silty clay loam, 0%–20% slopes	4c2

The Paleo Indians probably derived from those migrants that entered North America via the Bering Land Bridge and traveled south in several directions. One branch of these peoples entered the Tennessee area about 10,000 to 15,000 before the present (BP). Recent excavations at Kentucky Lake indicate that the lower Tennessee Valley must have been found to be agreeable to the invaders since there are more traces of their occupancy here than in most other parts of the United States.

A second wave of immigrants, the Archaic Indians, followed about 6000 to 7000 BP. They established villages and hunted food with spears tipped with stone points. The bow and arrow had not yet been invented. They seem not to have developed a burial cult, since bones of their dead are found in shell heaps along with other animal bones.

Somewhere between 3000 and 2500 BP, the Woodland Indians moved into the area, coming not from the north like their predecessors, but from the forests of the east. Their mode of life was agricultural, hence they introduced corn and the art of making pots. They had bows and arrows which made them more efficient hunters. The later Woodland people built mounds for the interment of their dead, depositing them in layers until the mounds reached 10 to 15 feet in height.[51]

Much larger mounds were built by the Mississippian Indians, but for the purpose of erecting council houses on top. These people, spreading out from the Mississippi Valley, came to the Tennessee Valley about 1000 to 1100 AD. They made pottery of a distinctive style and raised corn, beans, squash, and pumpkins. They probably cremated their dead since few graves have been found. The dialect they spoke was from the Muskhogean language group which included the Creeks, the Chickasaw from northern Mississippi, and the Choctaw from south-central Mississippi.

The first French and English contacts with the Indians came in 1673, when they met the Chickasaw who claimed western and part of central Tennessee as a hunting ground.

The powerful Cherokee Nation had come into the southeast area and Tennessee about 900 AD and forced the Creeks and Yuchis to move out of their lands in the early 1700's. Fifteen years later they drove the Shawnee out of the Cumberland Valley, leaving only the Cherokee. Tennessee was a no man's land, crossed by trails, hunted on, but containing few permanent settlements.[52]

IV. INSTALLATION ACTIVITIES WITH A POTENTIAL FOR AFFECTING THE NATURAL RESOURCES.

A. Public Utilities.

Volunteer Army Ammunition Plant supplies its own requirements for steam, sewage disposal, solid-waste disposal, and water. Electricity is provided by the TVA, and telephone service is provided by South Central Bell, Inc. About 3.5 million kw-hr/month is used by ICI-US although monthly usage varies widely. No data are available for FCAI usage.

Steam is produced by two different systems. The primary system comprises three steam plants. Two package boilers are used for VAAP in building 415, burning either natural gas or oil for fuel, with a combined capability of 300,000 lb/hr. Four boilers in building 401-1 are leased to FCAI for power and two boilers in building 401-2 are inactive. The inactive boilers burn bituminous coal and would require modification if they were to be reactivated. The combined steam capability of all boiler facilities would be 1.2 Mlb/hr.[53]

The secondary steam production system consists of five waste-heat boilers which are energized at first by steam from the primary boilers and thereafter are maintained by the heat from the exothermic reaction involved in production processes.

The blowdown from all boilers is continuous and is necessitated by the buildup within the boiler of chemicals, largely siliceous compounds, in the feed-water. Three treatment compounds are added to the feed-water; Liqui-treat Cl®, Neutrameen NA-7®, and Corrogen®. The manufacturer claims that they are nontoxic to aquatic life. Boiler treatment data are shown in table 14. Blowdown release is into pond 4. No data are available for FCAI.

Sewage treatment is mostly supplied by two plants, one in the new acid area, a 5000-gal/day package aeration plant. The remainder of the plant, with the exception of the burning/burying ground, is serviced by a 150,000-gal/day trickling filter plant. Sewage from the change building (No. 767) at the burning ground is disposed of through a tile drainage system.

Effluents from the two plants are released through pond 5. Fecal coliforms are within State regulations and do not create a significant impact. Due to the high nitrogenous content of the wastes, BOD_5 is occasionally not in compliance with the VAAP NPDES permit limitations. There is no buildup of solids. Other chemical parameters are discussed in the section on water pollution.

There are other tile drainage systems (at the magazine area and batch TNT production area) which would not be used unless the batch process is reactivated. There is a large tile drainage system in the shop and administrative areas, but this system will be used only if all production ceases and the sewage treatment plants are shut down. FCAI uses a tile drainage system but no data are available on flow.

Water pumping stations (104 Mgal/d) on Chickamauga Lake and filtration plants (40 Mgal/d) on VAAP supply the water for VAAP. These facilities are leased to FCAI who supplies ICI-US with approximately 60 Mgal/mo of filtered, chlorinated, potable water. Backwash from the filtration plant is released into a Government-owned pond on leased land with overflow into pond 4. Raw water is provided for emergency use only, such as for deluge and cooling use on the TNT lines. A well at the burning/burying ground supplies water for fire control on the burning pads and for sanitary purposes in the personnel change building. There is a potential for contamination of this well by seepage from the burning pads and landfill.

No data are available for FCAI water usage.

B. Waste Disposal.

Salvageable materials consists of uncontaminated paper, wood, and metals. Metals contaminated with explosives are decontaminated by flashing and are sold along with the paper and wood by the property disposal representative. Waste oils are sold by bid to waste oil salvagers. (Some waste oil is used to flash the metals.)

Uncontaminated trash consists of nonsalvageable trash not contaminated by TNT such as nonrecycleable paper, wood, and plastics. These wastes are sent to the landfill; none are incinerated.

®Betz, Inc., Tycuose, Pennsylvania.

Table 14. The Quantities and Waste Characteristics of Boiler Blowdown

System	Location	No. of boilers	Total blowdown	Condensate recovery	Liquid-treat C1	Neutrameen	Corrogen
			lb/hr	%	lb/hr	lb/hr	lb/hr
Primary	Building 415	2	18,000	0	2.9*	2.9*	.8*
Secondary	Sulfuric Acid Regeneration Unit (SAR)	1	4,500	50	.63	.4	.1
	Ammonia Oxidation Production Unit (AOP)	1	900	80	.3	.3	.1
	Direct Strong Nitric Acid Unit (DSN)	1	1,200	80	.7	.5	.2
	Acid Fume Recovery Unit (AFR)	2	5,600	50	.8	.6	.2

*When SAR is operating and exporting steam, approximately 1/3 less treatment is required (personal communication, Mr. Edward C. Bingham, Senior Project Engineer, ICI-US). There are two AFR units which account for two boilers.

Contaminated trash consists of waste, scrap explosives, and TNT-impregnated trash. These wastes are burned in the open under controlled conditions and residue is buried. Incinerators will be installed in July 1978 and in December 1979 to replace open burning.

All information on solid wastes was obtained from the 1975 Annual Status Report on Environmental Programs and Activities, the EPA Air Pollutant Emissions Report, and the VAAP briefing brochure.[13,18,54]

Farmers' Chemical Association, Inc., has few solid wastes associated with production. It does not operate any landfills, incinerators, or open-burning grounds. The trash it produces is disposed of by the commercial sanitation firm, Browning-Ferris, Inc., of Chattanooga, Tennessee. The trash, which is believed to be uncontaminated, is dumped at the municipal sanitary landfill.[7,*]

1. Landfill.

The 84-acre burning/burying ground, in use since July 1970, is located in the north end of the plant. The trench currently in use will be filled by the end of 1977, at which time a new trench will be dug adjacent to the old one. Drainage from the landfill and burning pads empties into the Hamilton Branch.

After metal has been separated from the burned material, the residue, which was approximately 20 tons in CY 1974,[55] is buried along with uncontaminated trash in the sanitary landfill. In 1974, about 379 tons[55] of refuse were buried and about 272 tons, in 1975.[19]

The trash is dumped into 6- to 8-feet-deep trenches and covered once a week. There is some problem with drainage from these trenches, but it could be corrected by covering the trash daily as recommended in "Installation Solid Waste Survey Guidelines."[56] The old burning/burying ground, closed in 1970, is now the site of the new acid area.

The soils of the burning/burying ground area are poorly suited to this use since they belong to the Fullerton Series which are deep soils with a high clay content and a medium runoff. They have severe limitations for sanitary landfills due to seepage trenches, and they are poor for landfill cover due to their stoniness.

The site selection was governed by the provisions of AMCR 385-100 rather than by the suitability of the soil.

2. Open Burning.

Until the proposed incinerators are completed (July 1978–December 1979), open burning is the most efficient means of decontaminating TNT-impregnated wastes and disposing of scrap explosives (table 15).

According to the EPA Air Pollutant Emission Report for 1974 (completed November 1975), "frequency of burning (on VAAP) depends on volume of accumulation and atmospheric conditions . . .** In 1974, from March to December, there was an average of 24 burnings per month

*Mr. James Dickerson, FCAI Plant Manager, personal communication.

**These conditions are set by the Chattanooga-Hamilton County Air Pollution Control Bureau.

Table 15. Quantities of Material Disposed by Open Burning in FY74 and FY75

Material	Combustible	CY1974	CY1975
	%	ton	
Explosive waste	99	146.4	585.15
Contaminated paper	98	96.0	14.96
Contaminated wood	95	296.0	47.95
Waste acetone and benzene	99	0.9	1.0

with a range from 17 to 42.[54] Emissions from the burning grounds are considered by VAAP to create a nuisance – the emissions violate particulate emission regulations and open burning is prohibited by Chattanooga-Hamilton County Pollution Control Board regulations. However, this should be corrected upon completion of proposed incinerators: an open-pit air curtain incinerator (July 1978) for contaminated wastes, and a destruction-type incinerator (December 1979) for explosive wastes.

3. Recycling and Salvage.

All recycleable materials which are not contaminated are sold.[17] In 1975, the following materials were recycled.[19]

	Tons
Ferrous metals	365.3
Nonferrous metals	30.4
Paper products	24.8
Wood products	64.6
Rubber, etc.	8.2

TNT redwater, a byproduct of TNT purification, is sold to the pulp and paper industry as thick liquor (35% solids). Prior to 1969, redwater was incinerated and sold as ash (salt cake, sodium sulfate). The Tampella process, a method to recover SO_2 and soda ash from the redwater has shown great promise as a future means of disposing of redwater as well as cutting down on purchases of sulfur and soda ash.*

C. Contaminated Areas.

The entire production area can be considered contaminated with TNT from past production spills and from the hauling of TNT in the area. More specifically, the areas of heaviest

*Mr. E. C. Bingham, ICI-US, personal communication.

contamination include the batch TNT lines, the burning/burying ground, the old sanitary landfill, and the old burning/burying ground, which is now the new acid area.

The production area soil and buildings of FCAI are contaminated predominantly with ammonia, nitrate, urea, and chromium. A slightly contaminated area caused by heavy fallout of particulate emissions is located downwind from the production area. This is expected to clean itself naturally within 12 months, and it is not expected to occur again since particulate emissions have been drastically reduced.[7,*]

D. Manufacturing Emissions.

1. Air Emissions.

The major manufacturing units at VAAP that affect the air quality are as follows:

AOP – Weak Nitric Acid Plant (New Acid Area)

DSN – Direct Strong Nitric Acid Plant (New Acid Area)

SAR – Sulfuric Acid Regeneration Plant (New Acid Area)

AFR – Acid Fume Recovery Units (TNT Area)

Continuous-Type TNT Lines (TNT Area)

Batch-Type TNT Lines (TNT Area)

The air quality standards that apply to each of the above processes are shown in table 16. The locations of each facility are shown in figure 11.

a. AOP – Weak Nitric Acid Plant.

The new AOP plant has produced emissions with no visible color and whose average NO_x content is within the 200-ppm limit according to tests made in late 1974 by ICI-US.[19] The plant was inoperative during most of 1975 when a new combustor unit was being installed.

In December 1975, the AOP plant was in operation for a short time, but the emissions were not monitored. On 9 February 1976, the plant resumed operation, but after 12 hours, cracks developed on the top of the combustor shell forcing the unit to be run at only 50% of capacity for the next 3 days, after which the plant was shut down for repairs. A new DuPont unit was scheduled to be installed in early April 1976.[17]

b. DSN – Direct Strong Nitric Acid Plant.

The DSN emissions have been readily visible, with NO_x levels above the 200 ppm acceptable limit. The DSN operation was equipped with a larger capacity condenser which should help reduce NO_x emissions. The unit was operated for a short period in November and December

*Mr. James Dickerson, FCAI, personal communication.

Table 16. Existing Air Pollution Standards Applicable to Volunteer Army Ammunition Plant

VAAP sources and status	Federal regulations			Local regulations	
	Source	Emission rate	Ambient	Source	Ambient
New AOP (Ammonia Oxidation Process) to make 60% HNO_3	200 ppm	Objective of 3.0 lb of NO_x per ton of HNO_3 – currently NA	.05 ppm Outer perimeter of VAAP property	200 ppm	Same as EPA
Compliance	Yes	To be determined by USAEHA second quarter of 1975	Yes	Yes	Yes
DSN (Direct Strong Nitric Acid Process) to make 98.5% HNO_3	200 ppm	Objective of 3.0 lb of NO_x per ton of HNO_3 – currently NA	.05 ppm	200 ppm	Same as EPA
Compliance	To be determined by USAEHA second quarter of 1975	To be determined by USAEHA second quarter of 1975	Yes	To be determined	Yes
Compliance	To be determined by USAEHA second quarter of 1975	NA	Yes	To be determined	Yes
TYPE – NO_x AS NO_2					
Old Batch TNT Lines (5) Currently shut down	200 ppm	NA	.05 ppm	Same as EPA	Same as EPA
Compliance	No	NA	No	No	No
Old Acid and Fume Recoveries (3) Currently one in operation	200 ppm	NA	.05 ppm	Same as EPA	Same as EPA
Compliance	No	NA	No	No	No
New Continuous TNT Lines (6)	200 ppm	NA	.05 ppm	Same as EPA	Same as EPA
Compliance	To be determined	NA	To be determined	To be determined	
New Acid and Fume Recoveries	200 ppm	Objective of 3.0 lb of NO_x per lb of HNO_3 – currently NA	.05 ppm	Same as EPA	Same as EPA
Compliance	To be determined by USAEHA second quarter of 1975	To be determined by USAEHA second quarter of 1975	To be determined by USAEHA second quarter of 1975	To be determined by USAEHA second quarter of 1975	
TYPE – OXIDES OF SULFUR (SO_2, SO_3) SULFURIC ACID MIST					
SAR (Sulfuric Acid Regeneration Process) to make oleum	500 ppm SO_2		.03 ppm	500 ppm*	.03 ppm
	Opacity 20%			Opacity 20%	
	Objective of .15 lb of H_2SO_4 mist per ton of sulfuric acid: currently NA		None	0.5 lb of H_2SO_4 mist per ton of sulfuric acid (State standard)	None
Compliance	SO_2 – Yes		SO_2 – Yes	SO_2 – Yes	SO_2 – Yes
	H_2SO_4 mist – No			H_2SO_4 mist – No	
	Opacity – No			Opacity – No	
TYPE – PARTICULATES					
Burning Ground Open Burning, Waste Explosive Open Burning, Explosive Contaminated Wastes	Based on incinerator input		75 μ/cu m	Based on incinerator input	Same as EPA
Compliance	No		Yes	No	Yes

*Currently under consideration for relaxing to 1800 ppm.

NOTE: NA = Not applicable.

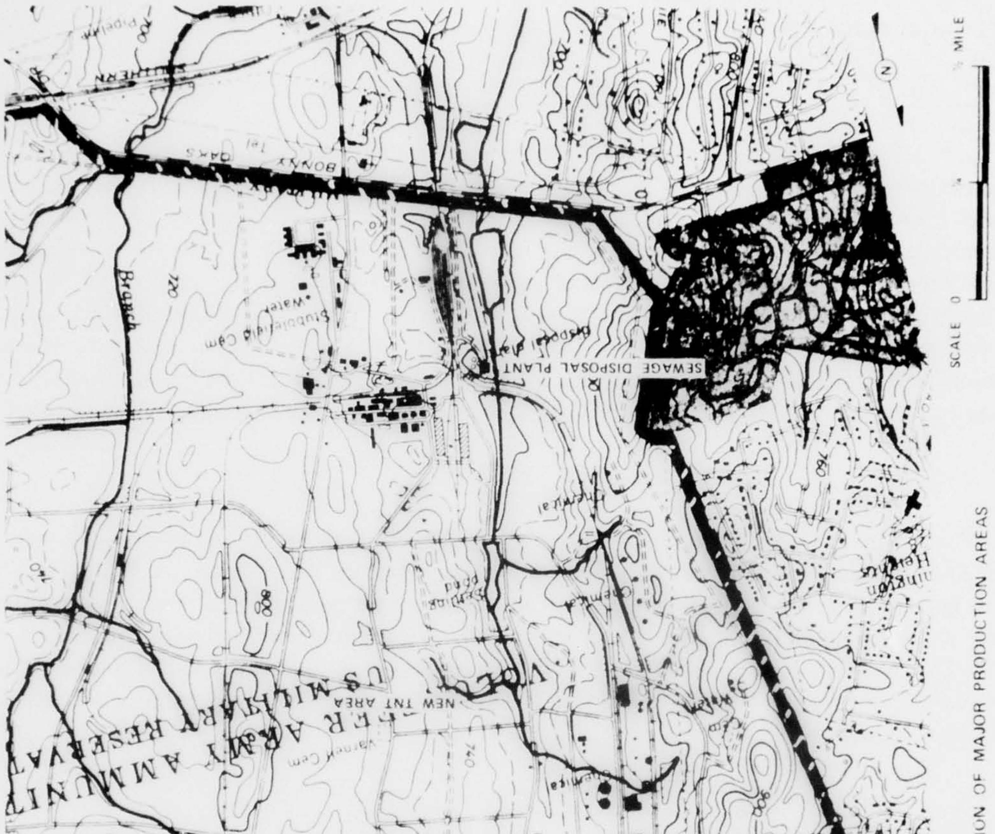


Figure 11. Locations of the Manufacturing Facilities and Waste Streams

1974.[18] However, the plant was shut down through 1975 and was expected to start up in mid-1976.[17] The stacks were retested on 8 and 9 June 1976 and were shown to be in compliance except during actual startup.*

c. SAR – Sulfuric Acid Regeneration Plant.

The Army Environmental Hygiene Agency (AEHA) monitored the SAR from 31 October to 14 November 1974. The results indicated: (1) general compliance with sulfur dioxide (SO_2) standards with an average output of 5.06 lb of SO_2/ton of H_2SO_4 produced; (2) noncompliance with the opacity standard which was found to be at the 90% level; (3) noncompliance with the sulfuric acid mist standards showing an average of 1.45 lb/ton of H_2SO_4; and (4) general compliance with NO_x standards.[18] The SAR was shut down most of 1975 and was restarted at the end of 1975. On 13 January 1976, the SAR stacks were monitored and emissions were still in noncompliance with State and local regulations for sulfuric acid mist and opacity (whose levels were 1.45 lb of mist/ton of sulfuric acid and 35% opacity, respectively).[17]

d. Continuous-Type TNT Lines.

The new continuous TNT lines are equipped with an acid and a fume recovery system which uses a John Zink thermal combustion furnace to abate NO_x emissions. When the absorption system is used with the combustion system in balance, emissions are not visible. Monitoring of its emissions has indicated that the fumes leaving the John Zink combustion furnace have ranged as low as 25 to 50 ppm and as high as 350 ppm which is in excess of the 220 ppm standard.[17] December 1975 monitoring by ICI-US showed that the new AFR was in compliance with the State and local standards.[17]

e. Batch-Type TNT Lines.

When batch TNT lines are in operation, emergency jets from nitration operations, wash-house emissions, as well as oil separation at the bi-nitration houses, constitute sources of NO_x emissions. Batch operations were discontinued 31 January 1975. However, five batch lines remain in reserve for total mobilization capabilities, but they will not be operated until such a condition exists.

A Production Engineering Test/Evaluation project relating to the VITOK absorption process system for NO_x pollution abatement was evaluated to determine whether this type of NO_x abatement could be applied to the old acid and fume recovery systems should the batch lines resume operation under a total mobilization commitment. Tests indicated that NO_x inlet concentrations of 30,000 ppm (3%) were reduced to an emission of 5,000 ppm (0.5%). This is a substantial reduction but the 0.5% level still would not conform with the existing local and State standards for NO_x.[17]

The redwater incinerators used to dispose of the redwater thick liquor from the TNT lines have not been used since 1968. The major mode of disposal since that time has been to sell the thick liquor to the paper industry. If in the future the incinerators are to be reactivated, it is not known whether they will be in compliance with State and local regulations. The redwater incineration is further discussed in section IV.A.

*Mr. E. C. Bingham, ICI-US, personal communication.

2. Water Pollutants.

The major water pollution sources discharge into one of the five main streams flowing on the installation. This section will discuss these streams (East Acid Stream, New Acid Stream, East TNT Stream, West TNT Stream, and the FCAI Stream) and the effluents that contribute to their water quality. Table 17 shows an inventory of the pollution sources entering each stream. The data in this report are representative of the field survey done by AEHA in 1972.[1]

a. East Acid Stream.

The East Acid Stream originates in the east acid area; water pollution sources affecting the stream are listed in table 16. The wastewater sampled in the stream was normally warm, averaging 93°F, with a pH averaging 2.3. Turbidity and suspended solids were found to be low, but dissolved solids and total solids were high. The average total organic carbon (TOC) of the stream was found to be 8.4 ppm which is less than the corresponding average of 14 ppm for untreated process cooling water. This characteristic was noted in most of the industrial waste streams where high acidity predominated. Nitrates remained stable, with an average of 6.6 ppm, while sulfates ranged from a low of 273 ppm to a high of 790 ppm. Sodium concentrations normally remained below 10 ppm.

b. New Acid Stream.

The New Acid Stream receives the majority of its flow from the discharges by the new acid area. A list of the primary sources of discharge is listed in table 17.

The effluent from the package sewage treatment plant is insignificant compared to the amount of industrial waste discharged. The wastewaters discharged from the new acid area have an extremely high-pollution potential. The dilution provided by the other waste streams was found to be sufficient to lower the concentrations of ammonia, nitrates, chlorides, sodium, and chromium to more acceptable discharge levels before leaving the plant; however, dilution in itself will not alleviate the pH and acidity problem of the waste stream. The pH ranges from 0.7 to 7.5, and acidity ranges from 0 to a high of 31,400 mg/l.[5 7] The biggest polluter of the stream is the SAR unit, and this is because the ILWTF is not operating at the present time. Comparisons of periods when the SAR was being operated versus periods when it was not support this hypothesis. Conductivity of the effluent of pond 5 was approximately twice as high during periods when the SAR plant was in operation compared to periods when the plant was down. The wastes from the new acid area are less acidic when the SAR is down, and less lime is required to neutralize the combined wastewater; therefore, the hardness of the water is reduced. Hardness levels fall from 570 to 290 ppm when the SAR is not operating. Similar reductions also occur with sulfate concentrations. Acid concentrations at this high a level represent a potential health hazard because of acid burns which would result if the wastewaters contacted the flesh.

c. East TNT Stream.

The East TNT Stream originates and flows on the east side of the TNT production area. The major sources of discharge are shown in table 2. The combined wastewaters are generally tinted yellow to orange; this was primarily due to the red discharge from the washhouses which have not been in use since 31 January 1975. (As noted in table 17, this stream is often colored by discharges from the new TNT area.) The pH of the stream varied from 2.2 to 7.3 with a mean value

Table 17. Inventory of Water Pollution Sources at Volunteer Army Ammunition Plant

A. East Acid Stream

1 - Surface drainage and leachate from Old East Acid Area no longer in use
2 - Compressor blowdown from 401-2
3 - Cooling water and surface drainage from 401-2
4 - Acid sewer from New Acid Area
   a. Sulfuric acid sewer from: (1) SAR, (2) "Sales Acid" Tank Farm, (3) AOP, and (4) DSN
   b. Nitric acid sewer from AOP and DSN
   c. Effluent from Industrial Liquid Waste Treatment Facility (ILWTF)

B. New Acid Area Stream

1 - Blowdown from primary boilers No. 415
2 - Storm sewers (surface drainage) from New Acid Area
3 - Effluent from 5,000 GPD Package Sewage Plant including effluent from laundry
4 - Overflow from cooling tower blowdown sump at ILWTF
5 - By-pass from ILWTF partial treatment

C. East TNT Stream

1 - Surface drainage from TNT lines 13, 14, 15, and 16 (no longer in use) and new TNT lines 1 to 6 *(only line 1 now in use)*
2 - Acid, red water and yellow water spills from New TNT line 1
3 - Drainage from two waste acid pits

D. East Stream into Pond 4

1 - East Acid Stream (above)
2 - New Acid Area Stream (above)
3 - East TNT Stream (above)
4 - Condensate and surface drainage from Red Water Plant

E. West TNT Stream

1 - Surface drainage from old batch TNT lines 1 to 6 (no longer in use)
2 - Effluent from 150,000 GPD Trickling Filter Sewage Disposal plant

F. FCAI Stream

1 - Filter backwash from water treatment plant
2 - Surface drainage and cooling water

G. West Stream into Pond 4

1 - West TNT Stream (above)
2 - FCAI Stream (above)
3 - Overflow from Silt Retention Pond

of 5.5, indicating that most of the time the discharges are slightly acidic. As expected, high conductivity and acidity values were obtained at the low pH levels. The wastewaters were fairly turbid and contained high concentrations of suspended solids. The dissolved solid concentrations were also high, but the actual poundage into pond 4 averages only 730 lb/day since the flow of the stream is small. The sulfate and nitrate concentrations vary with the changes in pH. Sodium concentrations in the stream seem to follow the same trends as nitrates and sulfates and are associated with nitrobody contamination. This is to be expected since sodium compounds (soda ash and sellite) are used in the purification of TNT.

d. West TNT Stream.

The West TNT Stream flows across the west section of the TNT production area. Its major waste sources are listed in table 17. The characteristics of the stream are warm temperatures and acidic conditions.[57] The increase in nitrates and sulfates with decreasing pH values indicates that both nitric and sulfuric acids are being discharged into the west TNT stream. The primary source of this is from leaks in the area's residual acid tanks.[57] The west TNT stream is also the largest contributor of suspended solids to pond 4, averaging approximately 2,260 lb/day. Most of the suspended solids in this stream are probably a result of silt suspension from the surface drainage of the area. This stream is also the largest contributor of redwater to Waconda Bay. Leaks from the acid storage tanks and inefficiencies in the TNT manufacturing process have caused discharges of sodium salt of nitrotoluene (redwater) into the west TNT stream.

e. FCAI Stream.

This stream originates on the land leased by FCAI. The major waste sources are shown in table 17.

The wastewaters can be characterized as being relatively clean with very erratic flow rates.[57] All of the parameters measured were normally within acceptable ranges, although several wide fluctuations were detected. The pH of the wastewater varied from a low of 5.0 to a high of 8.2 with the mean being 7.0. This stream is probably the second leading source of suspended solids emptying into ponds 4 and 5, the average quantity per day being approximately 1,450 lb. Most of these solids can be attributed to the filter backwash from the water-treatment plant.

3. Litigation.

a. Air Quality.

The Chattanooga-Hamilton County Air Pollution Control Board (APCB) sued ICI-US and the United States Army for failing to comply with its air-quality standards. The case was tried in Federal Court on 24 March 1975. After 1 day, the Judge directed the parties to reconcile their differences and to report back to him. When the case was reopened, the Judge dismissed it as being improperly presented.

A meeting requested by EPA was held 21 August 1975 at VAAP. The objective of the meeting apparently was an attempt by EPA to reach an agreement between the US Army and the APCB on what further action would be required to end the current air pollution litigation. The arguments advanced were that VAAP was in violation of open-burning standards; the acid and fume recoveries (AFR) and the SAR would be discussed later. With a request for a permit to open-burn, a waiver could be issued, but APCB has taken the position of "No Permit – No Waiver." This same

issue has been discussed with the same conclusion at every similar meeting since the Department of Defense issued a directive prohibiting all Federal installations from seeking air- or stream-pollution permits from local or State regulatory agencies.

One other point of contention on the part of APCB was their dissatisfaction with the failure of VAAP to supply them with hard and fast compliance dates. It was explained to them that the slow wheels of bureaucratic process have resulted in so much slippage to data that firm compliance dates are not realistic. Nevertheless, EPA requested that the US Army develop compliance dates for APCB with a proviso that slippage from dates would not cause further litigation. A Supreme Court decision (7 August 1976) ruled that federal facilities are exempt from State air pollution control permit programs or to State-issued National Pollutant Discharge Elimination System permits (Current Developments, Environment Reporter 7(6): 221-222). However, the State (Tennessee) does have the power to enforce a compliance schedule, an emission limitation, a standard of performance, or an emission standard that has been promulgated by EPA. As a result, all discharge limitations and compliance schedules must be established by EPA. Permits issued by EPA will incorporate the most stringent standards from the Federal, State, and local regulations. State or local air pollution regulation boards can still file suits against Federal facilities for permit and compliance violations if they act as private citizens.

At a subsequent meeting held on 12 November 1975 at VAAP, participants discussed all three air pollution sources. It was reported that the old No. 2 recovery had been shut down, and the new C-1 AFR was properly operating without a plume. The old No. 2 recovery was placed on standby, not to be operated except in a dire emergency. Also, it was resolved that the US Army would develop a compliance schedule for the incineration units to replace the open burning, and one for the SAR units. These schedules are discussed in the construction and modernization section (IV.H.).

b. Water Quality.

The State of Tennessee sued VAAP for failure to meet water-quality standards. Violation of standards occurred in the case of pH, nitrate-nitrite, oil and grease, phosphorus, BOD, COD, sulfate, TNT, dissolved solids, and color. The suit was tried in Federal Court on 24 March 1975 and was continued indefinitely. The State has indicated that it will drop the suit and accept the compliance schedule set up in the NPDES permit by the EPA. The compliance schedule is discussed in the modernization section (IV.H.).

E. Pest Control Measures.

All pesticides used on VAAP are applied by plant personnel who are supervised by a foreman certified by the Army as a pesticides applicator. The pesticides are stored in building 704 (table 18).

Insecticides are used mainly in the administration buildings only when there is a need. There is no regular schedule of application. In the past 5 years, two other applications were attempted.* Lindane and fuel oil was sprayed on approximately 3 acres of pine to control southern pine beetles but, due to the large number of the beetles, this spraying was considered ineffective and the idea was abandoned. Mosquitoes were a nuisance several years ago and an organophosphate insecticide was applied. No data are available on what was used and at what concentration.

*Mr. E. C. Price, ICI-US, personal communication.

Table 18. Pesticides Inventoried at VAAP

Pesticide name	1 May 1975	1 October 1975
Insecticides		
Diazinon (2%)	–	40 pounds
Dieldrin (15%)	5 pounds	–
Warfarin (.025%)	30 pounds	10 pounds
Chlordane (72%)	15 gallons	9 gallons
Chlordane (45%)	1.25 gallons	1 gallon
Chlordane dust (5%)	25 pounds	–
Sevin (90%)	–	20 pounds
Sevin (50%)	40 pounds	38 pounds
Pyrethrin aerosol (12 ounces)	60 each	93 each
Bagon bait (2%)	5 pounds	4 pounds
Diazinon (47.5%)	5 gallons	5 gallons
Cabaryl (80%)	20 pounds	20 pounds
Bagon 1.5 (13.9%)	3 gallons	3 gallons
Malathion (57%)	–	15 gallons
Aldrin	–	5 gallons
Eagles (Warfarin .025%)	–	20 pounds
Herbicides		
Silvisar 550	6 quarts	6 quarts
Maintain	1 gallon	–
Phytar 560	8 gallons	7 gallons
Tordon pellets	50 pounds	50 pounds
MH 30T	6 gallons	5 gallons
2,4,5-T (6 pounds per gallon)	5 gallons	–
2,4,D (4 pounds per gallon)	20 gallons	–
LV-33 [2,4,D and 2,4,5-T (2 pounds each per gallon)]	100 gallons	90 gallons
Hyvar X	500 pounds	–

Soil sterilants are commonly used to control weeds where it is not feasible to control them by cutting. These areas include railroad beds, road shoulders, and parking lots. This is done as the need arises and according to accepted practices.

Herbicides are used in large, vacant areas where it is not economical to control growth by mowing. Broadleaf weeds on the storage bunkers are controlled by herbicides because there is no other feasible control method.

F. Storage.

Storage facilities are provided for four classifications of materials: raw materials, waste products, finished products, and miscellaneous.

Raw materials consist of toluene, sulfuric acid, spent acid, ntiric acid, sellite, ammonia, lime, soda ash, and sulfur. These materials have main storage tanks plus smaller production feed tanks on the production line.

Waste products are predominantly redwater and yellowwater. Acid wash water and caustic water are mixed with yellowwater and disposed of through the redwater pond. Spent acid, a mixture of nitric and sulfuric acids, is a waste product which is recovered in the acid fume recovery unit. It is denitrated, recovered in the sulfuric acid recovery unit, and then burned to yield SO_2, the raw product in sulfuric acid production.

Finished products are stored in 200 magazines with capacities ranging from 30,000 to 500,000 lb of TNT each. The magazines are isolated and conform to safety regulations regarding storage of explosives.

Miscellaneous storage includes all materials incidental to production. These include gasoline for vehicles, boiler feed water chemicals, diesel fuel oil, and water.

Most storage tanks have dikes around them for spill control purposes. Those tanks without dikes in the event of a spill would empty into one of the treatment ponds (4, 7, or COE) where neutralization and cleanup can be performed before the effluent reaches Waconda Bay. However, there are two sulfuric acid storage tanks (facilities numbers TK-395 and TK-39) each holding 1,200 gallons of 68% residual acid which would spill directly into Waconda Bay without retention. There are plans to build dikes around these two tanks.*

G. Resource Management Programs.

1. Fish and Wildlife Management.

The goal of this program is to improve and develop desirable fish and wildlife habitat. The plan is accomplished through a cooperative agreement between VAAP, the US Fish and Wildlife Service, and the Tennessee Wildlife Resources Agency.

Through this agreement, stocking programs have been conducted on the installation. In the fall of 1971, the Tennessee Game and Fish Commission (now called the Tennessee Wildlife

*Mr. E. C. Bingham, ICI-US, personal communication.

Resources Agency) released 146 pheasants. These pheasants were available through a State management program that has since been discontinued. The pheasant population failed to become established due to a lack of suitable habitat. Another stocking program in conjunction with a study on the population dynamics of game fish in small ponds was conducted by biologists from the University of Tennessee at Knoxville. The area selected for study was a 6- to 8-acre pond on the slope overlooking FCAI in the northwest corner of the installation.

The plant is closed to hunting and fishing due to ammunition storage functions. Hunting was permitted until 1971 in the areas shown on figure 12. Bow hunting has been allowed for management of the deer herd; however, the future of that sport on the installation is uncertain.

The present forest and land management plans favor wildlife development. Den trees are preserved, and fire prevention and timber harvesting practices cause openings in the woods, conducive to browsing and to small game habitat development.

The principal small game species on the installation are bobwhite, mourning dove, eastern cottontail, and gray squirrel.

2. Land Management.

The goal of the land management plan is to promote operational safety and efficiency of the plant's primary mission while improving the appearance and utilization of the ground.

The total area of VAAP is 7,297 acres. Of that, 5,571 acres are forested (figure 12). The remaining areas are classified as either improved, semi-improved, or unimproved.

The improved areas, totaling 220 acres and consisting primarily of grasses such as fescue, rye, and bermuda, are mowed once a week or as needed. This improved area includes mostly the lawns around the administrative area and several private cemeteries, the location of which are shown in figure 12. The only landscape planting occurs around the administrative area. There are 559 acres of semi-improved grounds. These include the ammunition storage area and firebreaks which are planted in fescue, rye, bermuda grass, and orchard grass. These areas are mowed twice a year. Also included are the road shoulders and the gravel around production areas from which the vegetation is eliminated by a soil sterilant. There are approximately 37 miles of 50-feet-wide firebreaks criss-crossing the woodland, running along the security fence, and dividing the magazine area. The remaining 947 acres are unimproved and not maintained under this plan. These include ponds and streams, roads and railroads, buildings, and areas adjacent to inactive facilities including those facilities which are leased to FCAI.

3. Forest Management.

The goal of this plan is to produce and maintain the highest quality timber the site can produce in keeping with the mission of the installation. Also included is the retention of a timber reserve of white oak and black walnut for defense or emergency requirements.

Of the total 7,297 acres on the installation, 5,571 acres are utilized in the Forest Management Plan. The species grown and harvested in this plan are loblolly pine, shortleaf pine, black cherry, hickory, white oak, yellow poplar, and black walnut. The installation is divided into five compartments as indicated in figure 12. Under the 5-year management programs, one of the

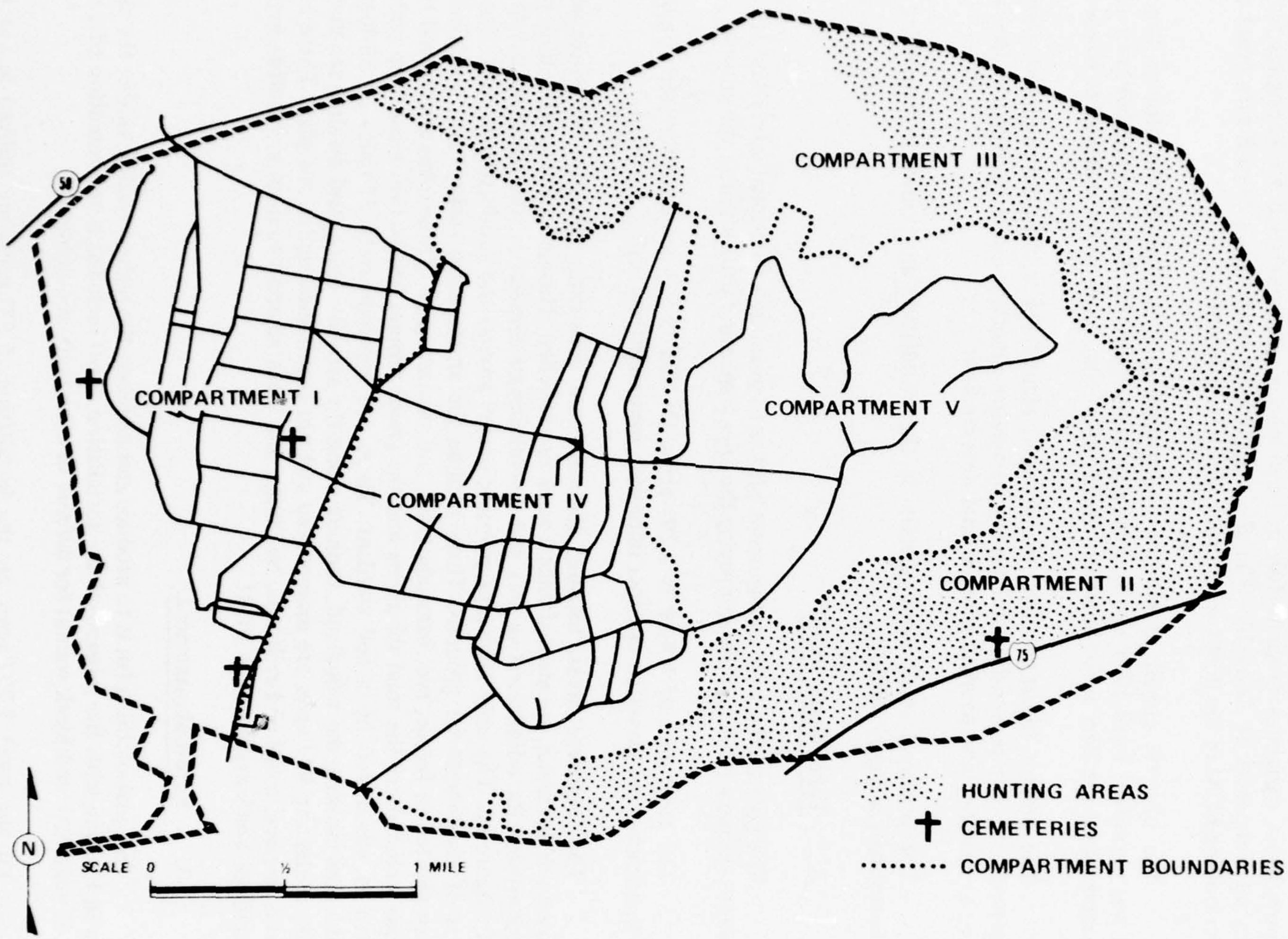


Figure 12. Hunting Areas, Cemeteries, and Woodland Management Compartments

compartments is selectively harvested annually through the silviculture system. However, intermediate cuttings control the density and composition of the growing stock. Timber marking and subsequent cutting is geared toward removing low-quality and low-valued trees and species in order that growing space may be occupied by high-quality stock.

Depending upon species or quality, harvested trees are sold as either pulpwood or saw logs. Unmerchantable hardwood, interfering with the growth of more valuable pine, is killed by use of 2,4,5-T amine salt injections.

Open lands, totaling 1,401 acres, have been reforested with loblolly, shortleaf, and white pine. Prescribed burning is not permitted at VAAP due to the mission.

The forest insects found on the installation are: southern pine beetle, red turpentine beetle, black turpentine beetle, and pine engraver beetle. Outbreaks of these insects are controlled by removing the affected trees. Technical assistance is obtained in case of a serious outbreak. Currently, the southern pine beetle has infected pine trees in several areas on the installation.

The important forest diseases found on the installation include little-leaf disease, southern fusiform rust, and heart rot. These diseases are controlled by harvesting the infected trees within the harvest schedule.

H. Pollution Abatement Programs: Compliance Schedules and Modernization Projects.

1. Air Quality.

A proposed schedule was established at the meeting at VAAP on 12 November 1975 between VAAP, EPA, and the Chattanooga/Hamilton County Air Pollution Control Bureau to bring the three remaining areas at VAAP into compliance with the air pollutant discharge limitations.

a. Sulfuric Acid Regeneration Facility.

(1) Decision as to whether or not an additional acid mist eliminator is required – 1 January 1976.

(2) Assuming that (1) above is yes, the following schedule is applicable:

Approval/disapproval of request for waiver of the COE construction prerogative – March 1976.

Remaining schedule, if waiver is approved, is as follows:

Approval of design funds	March 1976
Receipt of design funds	May 1976
Complete design	November 1976
Funding authorized – Congress	November 1976
Receipt of funds	February 1977
Begin construction	February 1977

Completed construction	December 1977
Compliance	March 1978

Remaining schedule, if waiver is not approved, is as follows:

Design criteria approved	March 1976
Begin design	August 1976
Complete design	January 1977
Funding authorized – Congress	November 1976
Advertise and award contract	April 1977
Complete construction	May 1978
Compliance	July 1978

b. Contaminated Waste Incinerator.

Approval/disapproval of request for waiver of the COE construction prerogative – February 1976.

Remaining schedule, if waiver is approved, is as follows:

Funds approved – Congress	November 1975
Design criteria approval	February 1976
Design complete	June 1976
Start construction	June 1976
Complete construction	February 1977
Compliance	March 1977

Remaining schedule, if waiver is not approved, is as follows:

Funds approved – Congress	November 1975
Design criteria approval	February 1976
Design complete	August 1977
Start construction	November 1977
Complete construction	July 1978
Compliance	August 1978

c. Explosive Waste Incinerator.

Decision on technology to be utilized – ARRCOM	January 1976
Design criteria approval	May 1976
Design complete	November 1977
Funds approved – Congress	November 1977

Start construction	February 1978
Complete construction	February 1979

As discussed earlier, the old acid fume recovery unit has been shut down and placed in standby condition to be utilized only under dire circumstances. The new acid fume recovery is operating in compliance with the pollution regulations and is expected to continue to do so.

2. Water Quality.

The modernization projects planned for VAAP were set up as the result of the NPDES permit on the water quality of the installation discharge. The projects and their compliance schedules are defined in the NPDES permit No. TN0052313 and are outlined below.

a. Provide facilities for the containment and treatment as necessary to the total facility discharge during normal (dry weather) conditions.

Submit concept design	30 November 1975
Submit 90% of plans	28 February 1976
Begin construction	30 June 1976
Submit status report	31 December 1976
Attain operational level	1 July 1977

b. Complete repairs to the holding pond for the ILWTF.

Submit status report	30 September 1975
Attain operational level	30 August 1976.

c. Meet design performance specifications for ILWTF.

Submit preliminary engineering report	31 January 1976
Submit final engineering report	30 June 1976
Complete plans and specifications	30 September 1976
Begin construction	31 December 1976
Attain operational level	1 July 1977

d. Repair or replace redwater and yellowwater transfer lines.

Submit status report	30 September 1976
Begin construction	31 December 1976
Attain operational level	1 July 1977

e. The permittee shall conduct a study to determine the feasibility and cost of achieving compliance with manganese, chromium, copper, and ammonia at discharge 001 as defined in the NPDES permit.

Complete preliminary field reconnaissance	30 September 1975
Complete all field investigations and submit status report	1 March 1976
Complete preliminary study report including preliminary engineering report	1 May 1976
Complete final report including conceptual design for required *treatment facilities or* corrective action	30 June 1976

V. SUMMARY AND RECOMMENDED ECOLOGICAL SURVEY PLAN.

Volunteer Army Ammunition Plant is located on the Tennessee River between the Cumberland and the Appalachian Mountains. The principal discharge from the acid plants and the TNT production lines at VAAP enters Lake Chickamauga. Normally, pH is adjusted with lime and solids are precipitated before discharge; however, acid spills, leaking pipes, and additional cooling-water discharges from FCAI (a lessee) frequently reduce the efficiency of the treatment. Occasionally, there are fish kills as redwater discharges and acid enters Waconda Bay. Upstream industrial and domestic wastewaters enter the lake from the Hiwassee River, although TVA believes that these wastes are largely assimilated. During the summer, waters with a high organic content emanating from the Hiwassee River remain undiluted and anoxic. In the lower lake, marine toilets and industrial discharges seriously degrade water quality. The effect or persistence of TNT in the sediments has not been determined. Friar Branch, draining south from VAAP, primarily receives high-nitrogen-containing waters from FCAI. FCAI expects to recycle most of its wastewater as treatment is upgraded.

The Chattanooga-Hamilton County Air Pollution Control Board has imposed stringent regulations to control and reduce particulate concentrations and opacity. The ambient standards for annual mean concentrations of nitrogen dioxide and opacity are consistently violated in the Chattanooga area by manufacturing, coal-burning, and automobile exhausts. VAAP is a major source of NO_2, SO_2, and sulfuric acid mist. Definitive studies have not been performed to evaluate the impact of these emissions on vegetation and human inhabitants downwind.

Both water and air quality at VAAP have improved as production levels have declined. VAAP has submitted compliance schedules which have been approved by EPA. Ambient air and water quality monitoring programs have been expanded and facilities for additional treatment of acid and TNT wastewaters are being constructed.

Runoff and surface drainage from the burning/burying ground now enters Hamilton Branch. In addition, the soils of the landfill are poorly suited for disposal because of high seepage and poor compacting for fill material. The presence of sinkholes in other areas where this kind of soil (Fullerton Series) is found indicates that seepage is a potential problem.

Ecological surveys at VAAP will investigate the environmental fate of TNT in Waconda Bay. The preliminary results indicate that the effluent can be characterized by its high conductivity and biostimulatory effects. As a result of this survey, the distribution of TNT photolysis products will be determined in Waconda Bay and VAAP – induced changes in water quality will be

evaluated. Complementary surveys of benthic macroinvertebrates and algae will also be performed. The first survey emphasized data on TNT distribution and macroinvertebrate and algal communities downstream of the VAAP discharge. Such surveys are intended to evaluate changes caused by pollution abatement from baseline conditions established during previous surveys. After these results are available, future needs can be determined.

LITERATURE CITED

1. World Almanac. Almanac Press. New York, New York. 1975.

2. Quality of Water in Chickamauga Reservoir. Prepared by the Stream Sanitation Staff, TVA, Chattanooga, Tennessee. July 1964.

3. Climatological Data Summary for Chattanooga, Tennessee. US Climatological Data Center, NOAA, Asheville, North Carolina. 1975.

4. Helms, G. T., *et al* 1970. Chattanooga, Tennessee – Rossville, Georgia Interstate Air Quality Study. 1967-1968. US Department HEW, National Air Pollution Control Administration. Durham, North Carolina.

5. Tennessee Air Pollution Control Regulations. Effective April 3, 1972. Amendments December 15, 1972, October 9, 1973, and May 17, 1974. Tennessee Division Air Pollution Control, Department of Public Health, Nashville, Tennessee.

6. Annual-Fiscal Report January 1972 – June 1973. Department of Public Health, Division Air Pollution Control, Nashville, Tennessee.

7. Annual Report July 1973 – June 1974. Tennessee Air Pollution Control Division, Department of Public Health, Nashville, Tennessee.

8. Annual Report July 1974 – June 1975. Tennessee Air Pollution Control Division, Department of Public Health, Nashville, Tennessee.

9. Carpenter, Benjamin, Poole, Kenneth W., and Jackson, Donald W. Prevalence of Chronic Respiratory Disease in Chattanooga. Effects of Community Exposure to Nitrogen Oxides. Air Pollution Technical Document APTD-0720:161. Environmental Protection Agency, Research Triangle Park, North Carolina. 1971.

10. Quality of Water in Chickamauga Reservoir, Tennessee Valley Authority, Division of Health and Safety, Chattanooga, Tennessee. 1964.

11. Chattanooga Waste Discharges. Part I. Upstream from the City Water Intakes. Technical Study Report TS-04-73-12. Environmental Protection Agency, Region IV, Surveillance and Analysis Division, Athens, Georgia. September 1972.

12. Aquatic Field Survey at Volunteer Army Ammunition Plant, Chattanooga, Tennessee. Preliminary Draft. February 1976. Water and Air Research, Inc., Gainesville, Florida.

13. Huff, Bernard, Smrchek, J., Snyder, R., Wheeler, J., and Hogan, T. 1975. Evaluation of Effects of Volunteer Army Ammunition Plant Wastes on Aquatic Life in Waconda Bay, Chickamauga Lake, Chattanooga, Tennessee. WAPORA, Inc., Contract No. DAMD 17-74-C-4138, Charleston, Illinois.

14. Briefing Brochure. Volunteer Army Ammunition Plant, Chattanooga, Tennessee.

15. Volunteer Army Ammunition Plant Basic Unit History, 1942-1966, With Eight Annual Supplements, 1966-1974. Chattanooga, Tennessee.

16. ICI America, Inc., Volunteer Army Ammunition Plant, Fish and Wildlife Management Plan, Engineering Section. Contract No. DAAA09-C-0086. February 1966. Revised December 1973.

17. Hauze, R. C. Pollution Status Memorandum. Project PAA 5754114, Task 1, VAAP (PE-AAP-76). June 1975.

18. ICI-US, VAAP, Ambient Air Quality Reports, Average Daily Monitoring Data. 1966-1974.

19. ICI-US, VAAP, Annual Status Report on Environmental Programs and Activities. 1975.

20. National Pollutant Discharge Eliminating System (NPDES) Permit No. TN0002313. Issued to VAAP, Chattanooga, Tennessee.

21. Evaluation of Effects of VAAP Wastes on Aquatic Life in Waconda Bay, Chickamauga Lake, Chattanooga, Tennessee. January 10, 1975. Contract No. DAMD 17-74-C-4138, WAPORA, Inc.

22. Aquatic Field Survey at VAAP, Chattanooga, Tennessee. February 1976. Air and Water Research, Inc., Gainesville, Florida.

23. ICI-US, VAAP, NPDES Monitoring Data.

24. Tennessee Valley Authority, Environmental Impact Statement, Sequoyah Nuclear Plant Units 1 and 2, Chattanooga, Tennessee. February 13, 1974.

25. Tennessee Valley Authority, Environmental Impact Statement, Brainerd Area Flood Relief Plan, Chattanooga, Tennessee. July 10, 1974.

26. Caplenor, Donald. An Annotated List of the Vascular Plants of the Gorges of the Fall Creek Falls State Park, Jur. of the Tennessee Academy of Science, Vol 60, No. 2, 1965.

27. Forest Management Plan for VAAP, ICI America, Inc., Engineering Section. Contract No. DAAA 09-73-C-0086. February 1966, Revised March 1973.

28. Shanks, Royal E., and Sharp, Aaron J. Summer Key to the Trees of Eastern Tennessee, Department of Botany, University of Tennessee, Knoxville, Tennessee. Undated.

29. Shaver, Jesse M. Ferns of the Eastern Central States with Special Reference to Tennessee, Dover Pub., Inc., New York, New York. 1954.

30. Sharp, Aaron, J. Preliminary Keys to the Genera and Species of Tennessee Ferns, Department of Botany, University of Tennessee, Knowxville, Tennessee. Undated.

31. Sharp, Aaron J. Taxonomic and Ecological Studies of Eastern Tennessee Bryophytes. The American Midland Naturalist. Vol 21. p 2. The University of Notre Dame, South Bend, Indiana. March 1939.

32. Skorepa, A. C. A Catalog of the Lichens Reported from Tennessee. The Bryologist. Vol 75. p 4. Winter 1972.

33. Phillips, Haskell. Foliose and Fruticose Lichens from Tennessee. Reprinted from the Bryologist. Vol 66. p 2. Summer 1963.

34. Dey, Jonathan. Two Lichens (Parmeliae) New to the Southern Appalachian Mountains. The Bryologist. Vol 76. p 4. Winter 1973.

35. Helms, Grady, *et al.* Chattanooga, Tennessee – Rossville, Georgia Interstate Air Quality Study, US Department of Health, Education, and Welfare, Public Health Service, Environmental Health Service, National Air Pollution Control Administration, Durham, North Carolina. October 1970.

36. Sharp, Aaron, J. Rare Plants of Tennessee. The Tennessee Conservationist. Vol XL. p 7. July 1974.

37. Letter, to Dr. F. Prescott Ward, Edgewood Arsenal, from Billy Headden, Acting S.R.C., USDA, Soil Conservation Service, Nashville, Tennessee. December 4, 1975.

38. Howell, J. C., and Conaway, C. H. Observations on the Mammals of the Cumberland Mountains in Tennessee. Jour. TN Acad. Sci. *27*:153-158 (1952).

39. Conaway, C. H., and Stowell, J. C. Observations on the Mammals of Johnson and Carter Counties, Tennessee. Jour. TN Acad. Sci. *28*, 53-61 (1953).

40. Anthony, H. E. Field Book of North American Mammals. G. P. Putman's Sons, New York, New York. 1928.

41. Hamilton, W. J. Jr. The Mammals of Eastern Untied States. Hafner Publishing Company, New York, New York. 1963.

42. Alsop, F. J. A Preliminary List of Tennessee Birds. The Migrant *43*:57-64 (1972).

43. Ganiers, A. F. Birds of Tennessee: Preliminary List Compiled by Tennessee Ornithological Society. Tennessee Department of Fish and Game. 1917. Revised 1933.

44. Ash, E. C., Jr. Some Reptiles from Southeastern Tennessee and North Georgia. Jour. TN Acad. Sci. *20*:261-265 (1945).

45. Gentry, G. Herptile Collections from Countys in the Vicinity of the Obey River Drainage, Tennessee. Jour. TN Acad. Sci. *16*:329-332 (1941).

46. Tennessee Valley Authority, Environmental Statement, Flood Relief Plan. July 12, 1974.

47. Schoup, C. S. A Bibliography of Zoology of Tennessee and the Tennessee River Valley. US Atomic Energy Commission. Office of Information Services, Oak Ridge, Tennessee. 1974.

48. Soil Survey Interpretations for Woodlands in the Cumberland Plateau and Mountains and the Southern Appalachian Ridges and Valley of Alabama, Georgia, and Tennessee. Progress Report W-11. US Department of Agriculture, Soil Conservation Service, Fort Worth, Texas. May 1969.

49. Hickman, R. C., and Lynch, V. J. Chattanooga Shale Investigations. Report of Investigations, 6932. Bureau of Mines, US Department of Interior. April 1967.

50. Hershey, R. E., Williams, L., Crentz, W. L., and Miller, J. W. Estimate of Known Recoverable Reserves and the Preparation Characteristics of Coking Coal in Hamilton County, Tennessee. Report of Investigations 5263. Bureau of Mines, US Department of Interior. October 1956.

51. Silverberg, R. Mound Builders of Ancient America. New York Graphic Society, Greenwich, Connecticut. 1968.

52. Folmsbee, Stanley J., Corlew, R. E., and Mitchell, Enoch L. Tennessee, A Short History, University of Tennessee Press, Knoxville, Tennessee. 1969.

53. Bingham, E. C. Environmental Impact Assessment, Volunteer Army Ammunition Plant. Chattanooga, Tennessee. October 1975.

54. Environmental Protection Agency. Air Pollutant Emissions Report, Stack and Pollutant Emissions Data. November 14, 1975.

55. Army Environmental Health Agency, Air Pollution Engineering Source Sampling Study No. 21-036-74/65, Sulfuric Acid Regeneration Unit, VAAP, Chattanooga, Tennessee. 31 October to 14 November 1974.

56. Schanche, G. W., Greep, L. A., and Donahue, B. Installation Solid Waste Survey Guidelines. Technical Report E-75. Construction Engineering Research Laboratory. October 1975.

57. US Army Environmental Hygiene Agency Water Quality Engineering Special Study No. 24-033-72/74. Industrial Waste Study, Volunteer Army Ammunition Plant. 14 August to 1 September 1972.

APPENDIX A

NPDES AVERAGE MONTHLY DATA FOR POND 5

JANUARY 1974 TO FEBRUARY 1976

AVERAGE VALUES

Year 1974	Flow	Pond 5 – VAAP Temperature	Dissolved oxygen	pH	BOD	Ammonia	COD	Sulfate	Chromium	Nitrate and nitrite	Phosphorus	Copper
	Mgal/d	°F										
January	*	55	9.6	7.6	11.6	5.30*	23.7	225	0.00	6.80	0.00	0.02
February	*	54	8.0	7.6	7.23	3.86	32.7	262	0.00	6.88	0.00	0.00
March	7.12	61	8.0	7.3	15.9	3.22	33.1	192	0.00	6.33	0.01	0.01
April	*	66	7.1	7.3	5.70	2.40	27.3	152	0.00	6.46	0.02	0.03
May	5.90	75	6.6	7.3	3.50	3.10	17.4	151	0.00	8.20	0.01	0.03
June	5.90	79	6.7	7.3	2.90	2.30	26.1	166	0.00	7.38	0.01	0.02
July	6.10	83	6.2	7.1	5.70	2.80	20.0	127	0.01	7.42	0.01	0.02
August	5.68	83	5.9	7.3	4.87	2.50	20.7	191	0.00	6.33	0.00	0.04
September	4.72	76	6.1	7.3	4.30	1.80	17.0	159	0.00	9.61	0.01	0.03
October	4.55	68	8.6	7.3	5.31	0.55	16.8	144	0.02	5.36	0.02	0.02
November	3.96	60	8.5	7.3	7.80	0.33	18.7	148	0.00	3.17	0.03	0.03
December	4.83	53	9.1	7.2	11.9	0.62	22.2	118	0.00	4.08	0.00	0.00
Average	5.42	68	7.5	7.3	7.23	2.40	23.0	170*	0.00	6.50	0.01	0.02

	Iron	Manganese	TNT and nitrobody	Lead	Mercury	Residual chlorine	Phenol	Kjeldahl nitrogen	Total dissolved solids	Total suspended solids	Settled solids	Oil and grease
January	0.03	0.54	0.42	nil	nil	0.00	*	*	396	39.2	<0.1	2.57
February	0.09	0.46	0.48	nil	nil	0.00	*	*	463	14.0	<0.1	19.0
March	0.09	0.26	0.10	nil	nil	0.00	*	*	722	7.0	<0.1	39.0
April	0.43	0.34	0.05	nil	nil	0.00	*	*	384	10.0	<0.1	8.00
May	0.02	0.22	0.09	nil	nil	0.00	*	*	573	9.0	<0.1	16.0
June	0.15	0.19	0.01	nil	nil	0.00	*	*	445	7.0	<0.1	9.00
July	0.14	0.29	0.01	nil	nil	0.00	*	*	330	13.0	<0.1	26.0
August	0.12	0.19	0.00	nil	nil	0.00	*	*	495	14.7	<0.1	20.3
September	0.09	0.19	0.00	nil	nil	0.00	*	*	524	7.6	<0.1	12.5
October	*	0.11	0.01	nil	nil	0.00	*	*	284	5.3	<0.1	10.4
November	0.10	0.13	1.20	nil	nil	0.00	*	*	485	10.0	<0.1	12.3
December	0.00	0.44	0.00	nil	nil	0.00	*	*	341	7.57	<0.1	4.13
Average	0.11	0.28	0.20	nil	nil	0.00	*	*	454	12.0	<0.1	14.9

*Data invalid or no data.

AVERAGE VALUES

Year 1975	Flow	Temperature	Dissolved oxygen	pH	BOD	Ammonia	COD	Sulfate	Chromium	Nitrate and nitrite	Phosphorus	Copper
	Pond 5 – VAAP											
	Mgal/d	°F										
January	4.30	52	8.3	6.80	9.60	0.47	18.7	125	0.01	4.09	nil	0.01
February	4.20	53	9.2	6.80	6.00	0.47	19.1	194	0.00	4.41	nil	0.01
March	3.60	53	8.6	7.30	9.87	0.47	21.4	325	0.00	14.5	0.07	0.02
April	2.91	60	7.5	7.10	10.0	0.56	28.6	497	0.01	19.7	0.01	0.03
May	2.8	71	5.8	7.2	9.76	0.63	24.9	514	0.02	72.1	0.01	0.03
June	2.8	79.5	6.2	3.3-10.7	5.3	0.40	17.3	61	0.02	7.2	0.01	0.05
July	2.6	82.5	7.4	2.6-10.8	2.06	0.35	14.4	35.9	0.03	2.61	0.01	0.01
August	2.6	85.1	6.61	2.9-10.8	2.90	0.62	10.2	74.2	0.02	2.29	0.001	0.01
September	3.3	75.0	7.24	3.6-11	3.70	1.16	13.4	64.4	0.27	3.60	0.02	0.02
October	4.2	68.7	8.38	5.2-11.3	6.91	0.97	20.1	392	0.03	14.0	0.00	0.02
November	4.45	59	8.7	6.35-11.2	18.0	1.06	18.0	280	0.02	8.89	0.03	0.03
December	4.34	50.5	7.29	2.9-11	6.29	3.23	20.2	315	0.50	49.6	0.02	0.02
Average	3.51	65.78	7.6		7.53	0.866	18.9	240	0.04	16.9	.015	.022

	Iron	Manganese	TNT and nitrobody	Lead	Mercury	Residual chlorine	Phenol	Kjeldahl nitrogen	Total dissolved solids	Total suspended solids	Settled solids	Oil and grease
January	0.05	0.50	0.02	nil	nil	0.00	*	*	452	10	<0.1	5.2
February	0.06	0.65	1.21	nil	nil	0.00	0.00	*	553	12	<0.1	*
March	nil	0.47	1.61	nil	nil	0.00	*	*	1,362	13.9	<0.1	21.1
April	0.12	0.35	1.87	nil	nil	0.00	*	*	2,197	22.7	<0.1	8.63
May	1.1	0.31	1.02	nil	nil	0.00	*	*	2,188	16.2	<0.1	25.7
June	0.07	0.56	0.77	nil	nil	0.00	*	*	434	66.0	<0.1	1.8
July	0.31	0.25	0.58	nil	nil	0.00	*	*	367	17.4	<0.1	2.62
August	1.0	0.2	0.52	nil	nil	0.00	*	*	364	26.6	<0.1	1.95
September	0.58	0.30	0.51	nil	nil	0.00	*	*	433	30.5	<0.1	1.95
October	0.72	0.35	2.70	nil	nil	0.00	*	*	1,718	11.2	<0.1	16.9
November	1.17	0.45	1.29	nil	nil	0.00	*	*	993	12.6	<0.1	35.8
December	1.30	0.44	1.47	nil	nil	0.00	*	*	1,852	10.9	<0.5	2.78
Average	0.95	0.40	1.13	nil	nil	0.00	*	*	1,076	20.83	<0.1	11.31

*Data invalid or no data.

NPDES Average Monthly Monitoring Data

Parameter	January 1976			February 1976		
	Minimum	Average	Maximum	Minimum	Average	Maximum
Flow (Mgal/d)	3.88	5.53	9.45	3.88	4.96	13.23
Ammonia	0.50	3.63*	7.0*	1.00	1.78*	2.50*
BOD_5	4.4	7.4	9.8	2.1	6.5	10.6*
COD	14.4	21.4	47.0*	8.9	23.3	41.9*
Chromium	0.0	0.01	0.03	0.03	0.04	0.05
Copper	0.0	0.03	0.04*	0.04	0.07	0.09*
Dissolved solids	1503	1725*	2031*	344	1299*	2963*
Iron	0.44	0.44	0.44*	1.06	1.06	1.06*
Lead	0	0	0	0	0	0
Manganese	0.45	0.76	1.15*	0.30	0.51	0.64*
Mercury	0	0	0	0	0	0
Nitrate and nitrite	10.4	87.2	196*	11.4	32.1	84.0*
Oil and grease	3.20	16.4*	31.2*	4.10	21.2*	41.1*
Phenol	0	0	0	0	0	0
Phosphate	0.01	0.03	0.14*	0.01	0.06	0.25*
Settled solids	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
Sulfate	70.0	304	400*	78.0	234	540*
Suspended solids	2.00	16.1	47.0*	4.0	11.8	31.0
TNT and nitrobodies	0.20	1.09*	2.50*	0.50	1.02*	1.96*
Temperature (°F)	39.5	46.4	52.5	44.5	54.1	60.5
pH	6.2*	140 minutes	9.5*	3.1*	196 minutes	9.2*
Dissolved oxygen (DO)	2.80	7.60	11.0	–	–	–
Residual chlorine	0	0	0	–	–	–

* Exceeds NPDES Permit requirements.

APPENDIX B

COMPARISON OF WATER QUALITY IN WACONDA BAY AS DETERMINED BY WAPORA, WAR, AND VAAP

POND 5

NPDES Average Monthly Monitoring Data
1974 - 1975

AVERAGE VALUES

Waconda Bay - VAAP

1974	1st Quarter				2d Quarter				3d Quarter				4th Quarter				Yearly average 1974			
Location	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4
Parameter	Parts per million except for pH and temperature																			
Ammonia	2.40	0.80	0.10	0.10	1.40	0.20	0.10	0.10	1.90	0.20	0.10	0.10	1.30	0.10	0.30	0.10	1.75	0.33	0.15	0.10
COD	21.8	16.6	15.6	12.1	19.0	12.9	11.3	10.4	18.7	11.2	6.12	9.42	22.5	25.3	17.3	7.20	20.5	16.5	12.6	9.78
Dissolved oxygen	8.1	8.3	8.0	8.5	7.6	8.1	8.1	7.8	6.9	7.3	6.7	6.4	9.0	*	9.3	*	7.9	7.9	8.0	7.6
Manganese	0.41	0.05	0.03	0.02	0.08	0.00	0.00	0.00	0.10	0.01	0.01	0.01	0.20	0.00	0.03	0.00	0.20	0.02	0.02	0.01
Nitrate and nitrite	8.93	2.78	1.48	0.80	7.51	2.43	1.77	0.96	6.76	2.04	1.22	0.44	6.30	1.40	2.97	0.44	7.38	2.16	1.86	0.66
pH	6.6	6.9	6.9	7.0	6.7	7.4	7.5	7.5	7.2	7.4	7.4	7.3	7.3	7.3	7.3	7.3	7.0	7.3	7.3	7.3
Sulfate	151	37	18	15	173	74	16	15	120	25	15	14	127	25*	73	13	143	40	31	14
Temperature, °F	54	53	52	52	71	70	70	70	79	78	77	77	60	68	57	67	66	67	64	67
TNT and nitrobody	0.22	0.00	0.03	0.01	0.05	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.00	0.00	0.00	0.07	0.00	0.01	0.00
Total suspended solids	16	7	7	6	12	3	1	2	8	4	3	4	8	4	4	6	11	5	4	5
Total disseminated solids	483	187	116	89	287	107	83	78	199	90	79	77	478	83	104	75	362	117	88	80
Total phosphorus	nil	nil	nil	nil	nil	nil	nil	nil	nil	nil	nil	nil	nil	nil	nil	nil	nil	nil	nil	nil
Chromium	0.00	0.00	0.00	0.00	0.01	0.01	0.01	0.01	0.05	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.02	0.00	0.00	0.00
Copper	0.00	0.00	0.00	0.00	0.03	0.02	0.02	0.02	0.03	0.02	0.02	0.02	0.00	0.00	0.00	0.00	0.02	0.01	0.01	0.01
Iron	0.13	0.37	0.39	0.37	0.03	0.07	0.07	0.17	0.06	0.04	0.04	0.06	0.10	0.07	0.09	0.11	0.08	0.14	0.15	0.18
Lead	nil	nil	nil	nil	nil	nil	nil	nil	nil	nil	nil	nil	nil	nil	nil	nil	nil	nil	nil	nil
Mercury	nil	nil	nil	nil	nil	nil	nil	nil	nil	nil	nil	nil	nil	nil	nil	nil	nil	nil	nil	nil

NOTES: 1 = Entrance - Waconda Bay.
2 = Harbor entrance.
3 = Entrance to Harrison Bay.
4 = Upstream - Main channel Tennessee River.

*Data invalid or no data.

AVERAGE VALUES

Waconda Bay – VAAP

1975	1st Quarter				2d Quarter			
Location	1	2	3	4	1	2	3	4
Parameter	Parts per million except for pH and temperature							
Ammonia	0.72	*	0.06	0.08	0.27	nil	nil	nil
COD	14.3	*	5.07	4.40	14.4	10.6	9.00	6.8
Dissolved oxygen	5.0	*	5.0	5.0	5.0	8.6	5.0	7.5
Manganese	0.47	*	0.03	nil	0.18	*	0.06	0.05
Nitrate and nitrite	4.87	*	3.90	3.44	0.5	*	nil	nil
pH	7.00	*	7.50	7.40	6.8	*	7.1	7.2
Sulfate	116	*	39	11	60	10	15	13
Temperature, °F	48	*	45	45	58	64	52	59
TNT and nitrobody	1.21	*	nil	nil	nil	*	nil	nil
Total suspended solids	5	*	10	8	18	2	22	10
Total disseminated solids	404	*	140	91	249	42	*	175
Total phosphorus	0.02	*	0.02	0.02	.050	*	.045	.050
Chromium	0.00	*	0.00	0.00	0.00	*	0.00	0.00
Copper	0.02	*	0.01	0.01	0.00	*	0.00	0.00
Iron	0.14	*	0.22	0.21	0.22	*	0.23	0.24
Lead	nil	*	nil	nil	nil	*	nil	nil
Mercury	nil	*	nil	nil	nil	*	nil	nil

NOTES: 1 = Entrance – Waconda Bay.
2 = Harbor entrance.
3 = Entrance to Harrison Bay.
4 = Upstream – Main channel Tennessee River.

*Data invalid or no data.

WATER QUALITY SUMMARY

WAR and WAPORA Reports

	Water and Air Research Incorporated Data						WAPORA Data	
Dates	9-13 June 1975			11-15 August 1975			23 September 1974	
Location	1	2	3	1	2	3	1	3
Parameter	mg/l except where noted							
Alkalinity	46.5	48.8	48.6	50.4	55.3	54.7	60	60
Total sulfates	108	21.9	15.4	62.2	14.2	11.6	72	17
Total solids	285	99.5	110.5	198	145.5	151.5	335	93
Total disseminated solids	275.0	91.0	103.5	190.0	139.5	147.0	334	93
Total suspended solids	10.0	8.95	7.4	14.0	9.5	7.0	1	<1
Nitrates	5.04	0.555	0.405	2.08	0.455	0.39	2.32	1.48
Nitrites	0.251	0.022	0.02	0.181	0.0145	0.0095	0.73	0.07
Total Kjeldahl nitrogen	0.74	0.355	0.365	1.88	0.305	0.325	0.27	0.66
Ammonia	0.32	0.02	0.015	1.12	0.07	0.095	<0.25	<0.25
COD	9.2	6.25	5.9	5.8	4.95	3.85	23.8	72.6
TOC	7.1	5.5	6.1	4.8	5.2	7.05	62	11
Oil and grease							4	9
Copper (ppb)	7		<5				40	60
Lead (ppb)	15		17				<10	<10
Zinc (ppb)	<2		<2				25	10
Chromium (ppb)	<5		<5				20	20
Mercury (ppb)							9	14
DO	7.08	6.98	6.89	7.10	6.56	5.94		
Temperature, °F	75.2	75.29	74.3	80.6	81.23	80.69		
pH	7.5	7.75	7.7	7.7	7.75	7.65		
Specific condition	774	165.5	172.5	498	192.35	183.2		
Total hardness	125	65.4	64.2	105	71.4	65.2		
Chlorine	17.4	3.05	3.7	41.7	7.55	5.95		
Total phosphorus	0.48	0.11	0.08	0.018	0.0215	0.0225		

APPENDIX C

WOODY PLANTS FOUND IN THE VICINITY OF VOLUNTEER ARMY AMMUNITION PLANT 25

Trees

Common name	Scientific name
Loblolly pine	*Pinus taeda*
Eastern red cedar	*Juniperus virginiana*
Cherrybark oak	*Quercus falcata* var. *pagodaefolia*
Northern red oak	*Quercus rubra*
Southern red oak	*Quercus falcata*
Pin oak	*Quercus palustris*
Water oak	*Quercus nigra*
Willow oak	*Quercus phellos*
Swamp chestnut oak	*Quercus michauxii*
White oak	*Quercus alba*
Sweet gum	*Liquidambar styraciflua*
Red maple	*Acer rubrum*
Yellow poplar	*Liriodendron tulipifera*
Boxelder	*Acer negundo*
Silver maple	*Acer saccharinum*
Black willow	*Salix nigra*
Green ash	*Fraxinus pennsylvanica*
White ash	*Fraxinus americana*
Beech	*Fagus grandifolia*
Black cherry	*Prunus serotina*
Dogwood	*Cornus florida*
American elm	*Ulmus americana*
Pignut hickory	*Carya glabra*
Shellbark hickory	*Carya ovata*
Mockernut hickory	*Carya tomentosa*
Sugar maple	*Acer saccharum*
Persimmon	*Diospyros virginiana*
Black walnut	*Juglans nigra*
River birch	*Betula nigra*
Winged elm	*Ulmus alata*
Hackberry	*Celtis laevigata*
Sycamore	*Platanus occidentalis*
Black locust	*Robinia pseudoacacia*
Honey locust	*Gleditsia triacanthos*
Sassafras	*Sassafras albidum*
Ailanthus	*Ailanthus altissima*
Crab apple	*Malus angustifolia*
Blue beech	*Carpinus caroliniana*
Hawthorn	*Crataegus* sp.
Ironwood	*Ostrya virginiana*
Redbud	*Cercis canadensis*
Possum haw	*Ilex decidua*
Pawpaw	*Asimina triloba*
Mimosa	*Albizia julibrissin*

Shrubs	
Common name	Scientific name
Cane	*Arundinaria gigantea*
Oleaster	*Elaeagnus angustifolia*
Elaeagnus	*Elaeagnus macrophylla*
Strawberry bush	*Euonymus americanus*
Rose mallow	*Hibiscus* sp.
Rose of Sharon	*Hibiscus syriacus*
St. John's-wort	*Hypericum* sp.
Privet	*Ligustrum* sp.
Nandina	*Nandina domestica*
Jetbead	*Rhodotypos scandens*
Smooth sumac	*Rhus glabra*
Multiflora rose	*Rosa multiflora*
Brambles	*Rubus* sp.
Elderbery	*Sambucus canadensis*
Bladdernut	*Staphylea trifolia*
Rusty black haw	*Viburnum rufidulum*

Vines	
Common name	Scientific name
Cross vine	*Anisostichus capreolata*
Rattan vine	*Berchemia scandens*
Honeysuckle	*Lonicera japonica*
Virginia creeper	*Parthenocissus quinquefolia*
Poison ivy	*Rhus radicans*
Bullbrier	*Smilax bona-nox*
Sawbrier	*Smilax glauca*
Common greenbrier	*Smilax rotundifolia*
Grape	*Vitis* sp.

APPENDIX D

DESCRIPTION OF WOODLAND SUITABILITY GROUPS

A Woodland suitability group consists of soils that have similar tree growth rates and woodland management problems. Hazards and limitations that are especially important in management for the production of wood crops are described for each suitability group. Tree growth rate is expressed as site index which is the average height of the dominant and codominant trees in well-stocked, unmanaged stands at a given age. Generally a soil will have a higher site index on the lower part of a slope in comparison to the upper part, and northern and eastern exposures of slopes in hilly land compared to southern and western exposures.

The woodland suitability groups (WSG) are described below.

WSG-2o7. Loamy soils with high potential productivity; no serious management problems; suitable for southern hardwoods and pines.

WSG-2w8. Seasonally wet soils with high potential productivity; moderate equipment limitations and slight to moderate seedling mortality; suitable for southern hardwoods and/or pines.

WSG-2w9. Excessively wet soils with high potential productivity; severe equipment limitations and moderate to severe seedling mortality; suitable for water-tolerant hardwoods or pines.

WSG-3c2. Clayey soils with moderately high productivity; moderate equipment limitations and slight to moderate seedling mortality; best suited for southern pines.

WSG-3c8. Cherty soils, low in natural fertility; clay restricts upper level of soils more than one management problem, suitable for either needleleaf or broadleaf trees.

WSG-3f8. Fragmental soils with moderately high productivity; slight to moderate erosion hazard and equipment restrictions and moderate seedling mortality; suitable for needleleaf and/or broadleaf trees.

WSG-3o2. Soils with moderately high productivity; no serious management restrictions; suitable for needleleaf trees.

WSG-3o7. Soils with moderately high productivity; no serious management problems; suitable for southern hardwoods and/or pines.

WSG-3r8. Loamy soils on steep slopes with moderately high productivity; moderate erosion hazard and equipment limitations; suitable for needleleaf and/or broadleaf trees.

WSG-3w8. Seasonally wet soils with moderately high productivity; moderate equipment limitations and slight to moderate seedling mortality; suitable for needleleaf and/or broadleaf trees.

WSG-3x8. Stoney or rocky soils with moderately high productivity; slight to moderate erosion hazard and moderate equipment restrictions; suitable for needleleaf and/or broadleaf trees.

WSG-4c3e. Severely eroded soils with moderate productivity; moderate to severe erosion hazard and equipment restrictions and seedling mortality; best suited for needleleaf trees.

WSG-4d3. Moderate depth to shale; woodland restriction because of shallow root depth. Severe management problems; best suited for needleleaf trees.

WSG-4x3. Rocky soils with moderate productivity; slight to moderate erosion hazard and moderate to severe equipment restrictions and seedling mortality; best suited for needleleaf trees.

WSG-5x3. Rocky soils with low productivity; slight to moderate erosion hazard, moderate to severe seedling mortality and equipment restrictions; best suited for needleleaf trees.

DISTRIBUTION LIST FOR ARCSL-TR-77016

Names	Copies
CHEMICAL SYSTEMS LABORATORY	
OFFICE OF THE DIRECTOR	
Attn: DRDAR-CLG	1
SAFETY OFFICE	
Attn: DRDAR-CLF	1
PLANS & PROGRAMS OFFICE	
Attn: DRDAR-CLR-L	4
AUTHOR'S COPIES: Environmental Technology Division, Attn: DRDAR-CLT-E	40
BIOMEDICAL LABORATORY	
Attn: DRDAR-CLL	1
CB DETECTION & ALARMS DIVISION	
Attn: DRDAR-CLC-C	1
DEVELOPMENTAL SUPPORT DIVISION	
Attn: DRDAR-CLJ-I	4
Attn: DRDAR-CLJ-M	1
ENVIRONMENTAL TECHNOLOGY DIVISION	
Attn: DRDAR-CLT-E	1
MUNITIONS DIVISION	
Attn: DRDAR-CLN	1
PHYSICAL PROTECTION DIVISION	
Attn: DRDAR-CLW	1
RESEARCH DIVISION	
Attn: DRDAR-CLB	1
DEPARTMENT OF DEFENSE	
Administrator	
Defense Documentation Center	
Attn: Accessions Division	12
Cameron Station	
Alexandria, VA 22314	
Director	
Defense Intelligence Agency	
Attn: DB-4G1	1
Washington, DC 20301	
DEPARTMENT OF THE ARMY	
HQDA (DAMO-SSC)	1
WASH DC 20310	
OFFICE OF THE SURGEON GENERAL	
Commander	
US Army Medical Bioengineering Research & Development Laboratory	
Attn: SGRD-UBC	1
Attn: LTC L. Reuter	1
Fort Detrick, Bldg 568	
Frederick, MD 21701	

Names	Copies
HQDA (SGRD-EDE)	
Attn: LTC Charles Dettor	1
WASH DC 20314	
US ARMY HEALTH SERVICE COMMAND	
Commander	
US Army Environmental Hygiene Agency	
Attn: HSE-AA-L, Librarian, Bldg 2100	1
Attn: HSE-AA-E	2
APG-Edgewood Area	
Superintendent	
Academy of Health Sciences	
US Army	
Attn: HSA-CDC	1
Attn: HSA-IHE	1
Fort Sam Houston, TX 78234	
Commander	
US Army Institute of Surgical Research	1
Brook Army Medical Center	
Fort Sam Houston, TX 78234	
US ARMY MATERIEL DEVELOPMENT AND READINESS COMMAND	
Commander	
US Army Materiel Development and Readiness Command	
Attn: DRCSF	1
Attn: DRCRD-WB	1
Attn: DRCRD	1
Attn: DRCRD-ES	1
Attn: DRCIS-MD	1
Attn: DRCPA-E	1
Attn: DRCRO-I	1
5001 Eisenhower Ave	
Alexandria, VA 22333	
Commander	
US Army Foreign Science & Technology Center	
Attn: DRXST-IS1	2
220 Seventh St., NE	
Charlottesville, VA 22901	
Project Manager for Chemical Demilitarization and Installation Restoration	
Attn: DRCPM-DR, Bldg E4585	1
APG-Edgewood Area	
Redstone Scientific Information Center	
Attn: Chief, Documents	1
US Army Missile Command	
Redstone Arsenal, AL 35809	
Commander	
US Army Science & Technology Center-Far East Office	1
APO San Francisco 96328	

DISTRIBUTION LIST FOR ARCSL-TR-77016 (Contd)

Names	Copies
US ARMY ARMAMENT RESEARCH AND DEVELOPMENT COMMAND	
Commander	
US Army Armament Research and Development Command	
Attn: DRSAR-ASF	1
Attn: DRSAR-ASN	1
Attn: DRSAR-ISE	2
Dover, NJ 07801	
Commander	
Rocky Mountain Arsenal	
Attn: SARRM-MD	1
Denver, CO 80240	
Commander	
Pine Bluff Arsenal	
Attn: SARPB-ETA	1
Pine Bluff, AR 71611	
Commander	
Frankford Arsenal	
Attn: SARFA-T-4200	1
Attn: Library Branch, TSP-L	2
Bldg 51-2	
Philadelphia, PA 19137	
US ARMY TEST & EVALUATION COMMAND	
Record Copy	
CDR, APG	
Attn: STEAP-AD-R/RHA	1
APG-Edgewood Area, Bldg E5179	
CDR, APG	
Attn: STEAP-TL	1
APG-Aberdeen Area	
Commander	
US Army Tropic Test Center	
Attn: STETC-MO-A (Tech Library)	1
APO New York 09827	
Commander	
Dugway Proving Ground	
Attn: STEDP-PO	1
Dugway, UT 84022	
Commander	
US Army Test & Evaluation Command	
Attn: DRSTE-LG	1
Attn: DRSTE-ME	1
Attn: DRSTE-NB	2
APG-Aberdeen Area	

Names	Copies
DEPARTMENT OF THE NAVY	
Chief of Naval Research	
Attn: Code 443	1
800 N. Quincy Street	
Arlington, VA 22217	
Commander	
Naval Facilities Engineering Command	
Attn: Code 03	1
200 Stovall Street	
Alexandria, VA 22332	
Commander	
Naval Ordnance Systems Command	
Attn: ORD-03D	1
Washington, DC 20360	
Chief, Bureau of Medicine & Surgery	
Department of the Navy	
Attn: CODE 5	1
Washington, DC 20372	
Commander	
Naval Air Systems Command	
Attn: Code AIR-350E	1
Attn: Code AIR-53231B	1
Washington, DC 20361	
DEPARTMENT OF THE AIR FORCE	
HQ Foreign Technology Division (AFSC)	
Attn: PDRR	1
Wright-Patterson AFB, OH 45433	
HQ, USAF/SGPR	1
Forrestal Bldg	
WASH DC 20314	
Director	
Air Force Inspection and Safety Center	
Attn: IGD(AFISC/SEV)	1
Norton AFB, CA 92409	
Commander	
Armament Development & Test Center	
Attn: DLOSL (Technical Library)	1
Eglin AFB, FL 32542	
OUTSIDE AGENCIES	
Director of Toxicology	1
National Research Council	
2101 Constitution Ave, NW	
Washington, DC 20418	
US Public Health Service	
Room 17A46 (CPT Osheroff)	2
5600 Fishers Lane	
Rockville, MD 20857	

DISTRIBUTION LIST FOR ARCSL-TR-77016 (Contd)

Names	Copies
ADDITIONAL ADDRESSEES	
Commander USDRC Installations & Services Agency Attn: DRCIS-RI-IU Rock Island, IL 61201	1
Commander US Army Materiel Development & Readiness Command Munition Production Base, Modernization & Expansion Attn: DRCPM-PBM-EC/Project Manager Attn: DRCPM-PBM-EB/Mr. A. Selman Dover, NJ 07801	 1 1
Commander DA-DCSLOG Attn: DALO-AMP Washington, DC 20310	1
Department of the Army Attn: DAEN-ZCE Washington, DC 20310	1
Commander US Army Construction Engineering Research Laboratory Attn: CERL-ER Champaign, IL 61820	1
Office of Chief of Engineers Attn: DAEN-MCZ-E Washington, DC 20314	2
District Engineer US Army Corps of Engineers 6014 US PO & Courthouse 215 N 17th Street Omaha, NB 68102	1
District Engineer US Army Corps of Engineers Attn: HNDED-M Attn: HNDED-FC PO Box 1600 West Station Huntsville, AL 35807	 1 1
Commander Holston Army Ammunition Plant Attn: SARHO-E Kingsport, TN 47662	1
Commander Milan Army Ammunition Plant Attn: SARMI-S Milan, TN 38358	1
Commander Newport Army Ammunition Plant Attn: SARNE-S Newport, IN 47966	1
Commander Radford Army Ammunition Plant Attn: SARRA-IE Radford, VA 24141	1
Commander Sunflower Army Ammunition Plant Attn: SARSU-O Lawrence, KS 66044	5
Commander Volunteer Army Ammunition Plant Attn: SARVO-T Chattanooga, TN 37401	1
Environmental Protection Agency Attn: Mr Harry Ike 26 Federal Plaza/Rm 837 New York, NY 10007	1
Environmental Protection Agency Attn: Mr. Ben Lacey Curtis Building, 2d floor 6th and Walnut Sts Philadelphia, PA 19106	1
Environmental Protection Agency Attn: Mr. Arthur Linton 1421 Peachtree Street, NE Atlanta, GA 30309	1
Environmental Protection Agency Attn: Mr. Don A. Wallgren 1 North Wacker Drive Chicago, IL 60606	1
Environmental Protection Agency Attn: Mr. James Highland 1600 Patterson Street Dallas, TX 75201	1
Environmental Protection Agency Attn: Mr. Robert Koke (RM 249) 1735 Baltimore Street Kansas City, MO 64108	1
Environmental Protection Agency Attn: Mr. Keith Synder Lincoln Tower Suite 900 1860 Lincoln Street Denver, CO 80203	1

DISTRIBUTION LIST FOR ARCSL-TR-77016 (Contd)

Names	Copies
Environmental Protection Agency Attn: Mr. Irving Terzich 100 California Street San Francisco, CA 94111	1
Army Logistics Management Center Environmental Management Attn: LCDR/J.C. Bolander Fort Lee, VA 23801	1
Commander Volunteer Army Ammunition Plant Attn: SARVO-O Tyner, TN 37392	5
US Army Engineer Waterways Experimental Station Environmental Systems Division PO Box 631 Vicksburg, MI 39180	1
Director Center for Environmental Studies Virginia Polytechnic Institute & State University Blacksburg, VA 24061	1